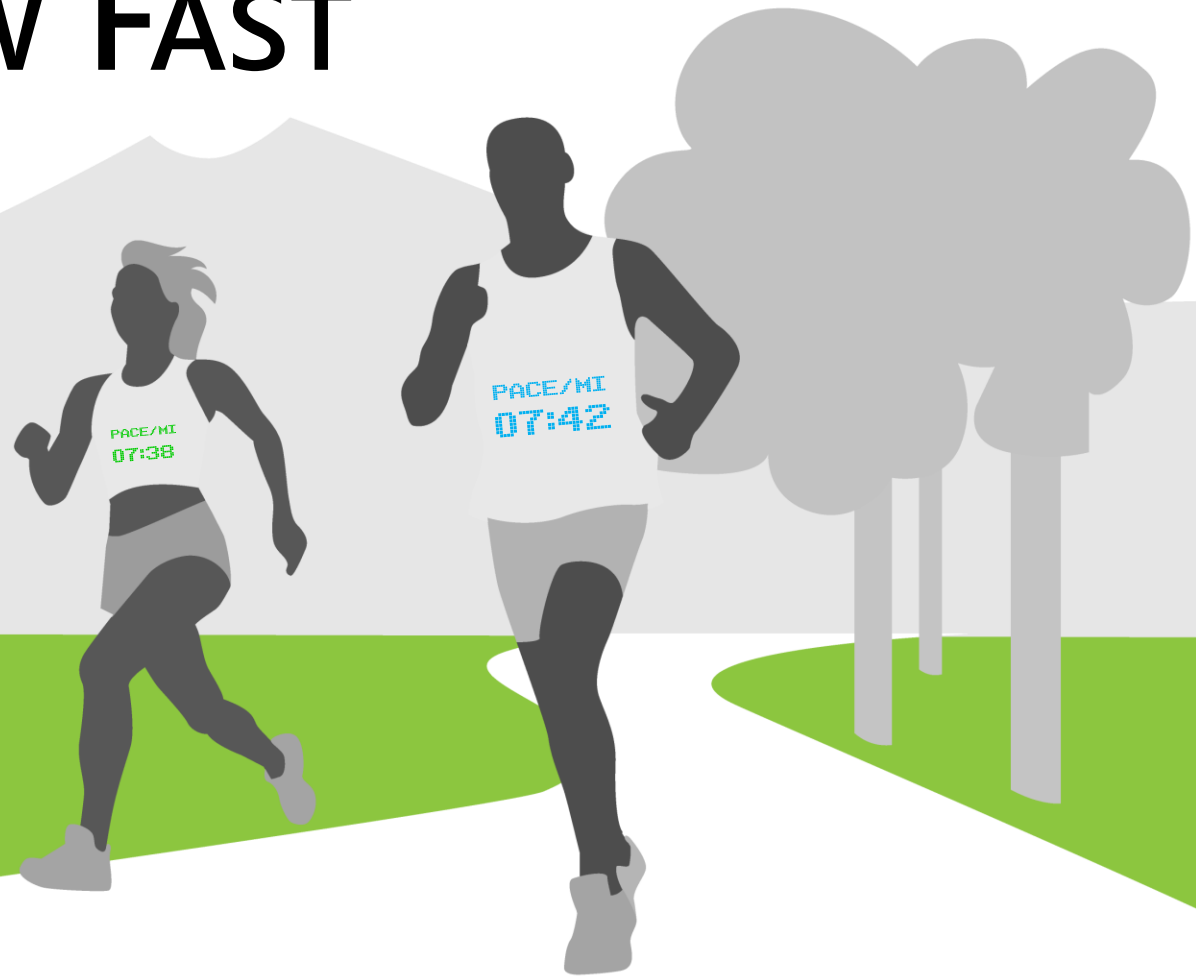


WHAT IF OUR CLOTHES COULD SHOW HOW FAST WE RUN?



Social Fabric Fitness:

The Design and Evaluation of Wearable E-Textile Displays to Support Group Fitness

Matthew Louis Mauriello

Michael Gubbels

Jon E. Froehlich

CHI 2104

April 30th, 2014





Plethora of Run Trackers



Designed for
the individual!



Group Running Benefits



Adherence to training



Educational benefits



Increases enjoyment



Aids training intensity



Group Running Benefits



Adherence to training



Educational benefits



Increases enjoyment



Aids training intensity

Social facilitation theories posit: the presence of others can increase a person's drive and focus (*e.g.*, Carron, 1996; Strauss, 2002)



SFF: Theoretical Underpinnings

Social Facilitation: A Self-Presentational View

Charles F. Bond, Jr.
Connecticut College

This article offers a self-presentational account of performance in others' presence. The account attributes social facilitation to the performer's active regulation of a public image, and it attributes social impairment to embarrassment following loss of public esteem. Individuals lose esteem by making numerous errors on difficult tasks. This self-presentational analysis is tested in a study of context effects in verbal learning. Two tasks are studied: a difficult task that includes a few simple items and an easy task that includes a few complex items. Consistent with the self-presentational analysis (but not with drive theories of social facilitation), the presence of an observer impairs the learning of simple items if those items are embedded within a difficult task. Also, an observer's presence does not impair the learning of complex items if those items are embedded within an easy task. Questionnaire responses suggest a naturally occurring confound between task difficulty and perceived failure.

The influence of the presence of others on individual behavior, a classic topic in social psychology, was studied extensively in the early 1900s (Dashiell, 1935). Contemporary interest in the topic derives from Zajonc's proposal (1965) that the presence of others acts as a source of generalized drive (Spence, 1956), and energizes the dominant response tendency to the exclusion of competing responses. Cottrell (1972) amended Zajonc's theory, contending that the presence of others arouses apprehension over evaluations. He claimed evaluation apprehension as a source of generalized drive.

This article proposes an alternative analysis of behavior in others' presence. Following Cottrell, the analysis attributes the influence of others' presence to the potential that presence gives them for evaluation. But Cottrell seemed to ignore the fact that the object of evaluation is the individual's per-

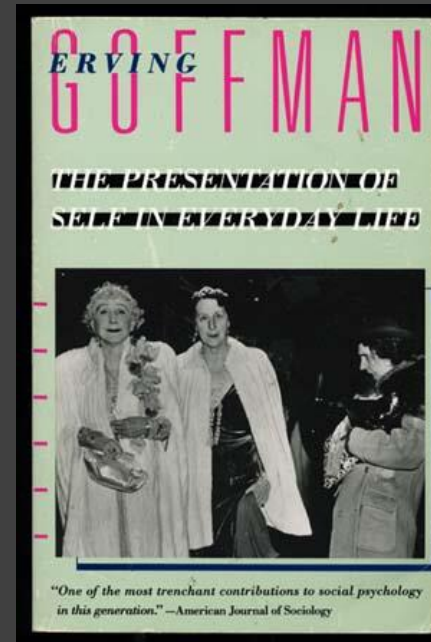
formance. The contingency of others' evaluation on the exhibited performance renders any *generalized* drive interpretation of their influence obtuse. Because a favorable evaluation could be secured or an unfavorable one avoided by competent performance, the nonactive presence of others provides an incentive for exhibition of socially valued behaviors (Geen, 1979). In addition the performance's status as the basis for evaluation gives that performance ongoing psychological significance for the performer. Lacking direct access to another's evaluation, the individual is left to infer it. The inference derives, in part, from a moment-by-moment retrospective self-evaluation that may influence subsequent behavior.

Erving Goffman elaborates related insights in his self-presentational analysis of social interaction (1959, 1967). Self-presentation theory depicts behavior in others' presence as attempts to control or reactions to a public self-image. According to Goffman when the individual appears before others, he or she will discover that an idealized self-image has been claimed. This acceptable image (called *face*) has a normative character. It obligates others to accord the individual the status claimed and obligates the

This article is based on a dissertation submitted to Duke University in partial fulfillment of the requirements for the PhD. I am grateful to Alan Levy, my dissertation adviser, for his guidance and to Mike Gottesman for help with this research.

Requests for reprints should be sent to Charles F. Bond, Jr., P.O. Box 1402, Connecticut College, New London, Connecticut 06320.

Journal of Personality and Social Psychology 1982, Vol. 42, No. 6, 1042-1050
Copyright 1982 by the American Psychological Association, Inc. 0022-3514/82/4206-1042\$00.75



Bond reframes social facilitation in terms of Goffman's presentation of self.

Presence of others can motivate the individual to project image of competence.

For tasks perceived to be too difficult, however, performance may actually decline as individual becomes self-conscious

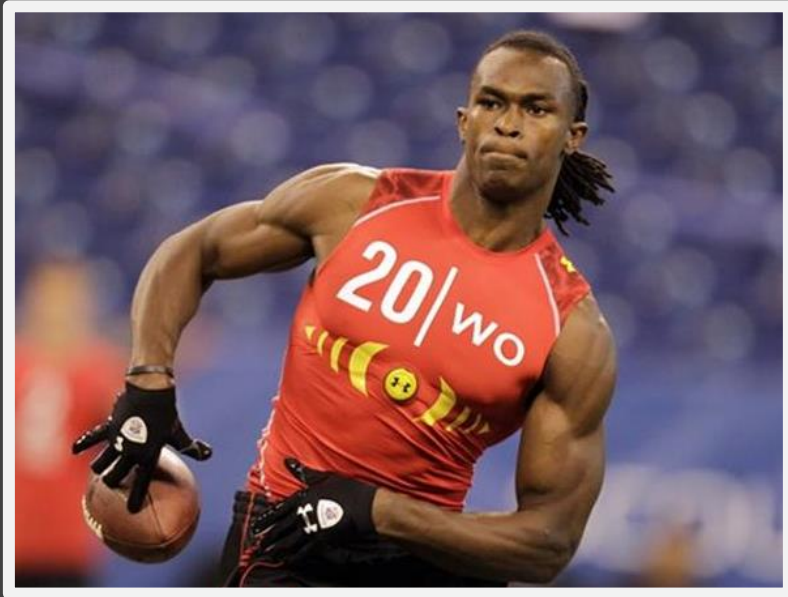
Potential Dichotomy

Increased motivation
vs. increased anxiety

SFF Externalizes
Performance



Wearables & Sports

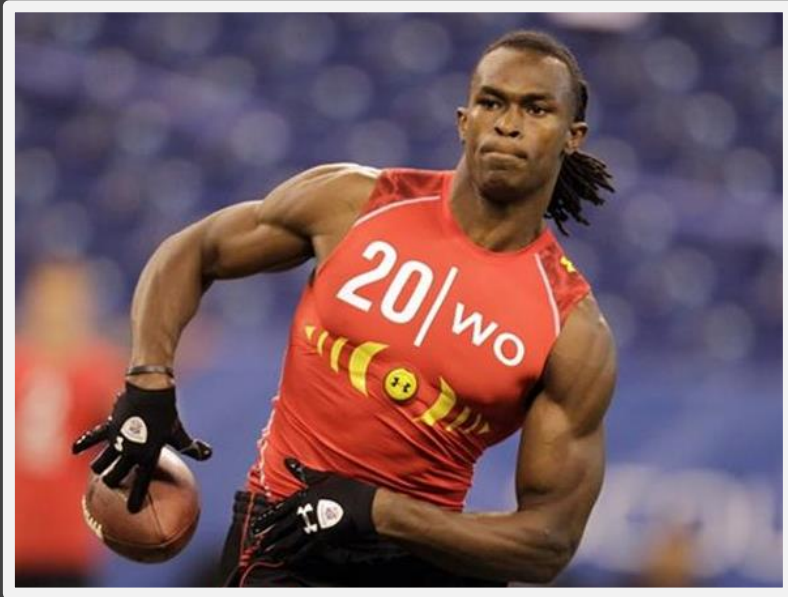


Wearables for **Sensing**



Wearables for **Sensing & Visualization**

Wearables & Sports

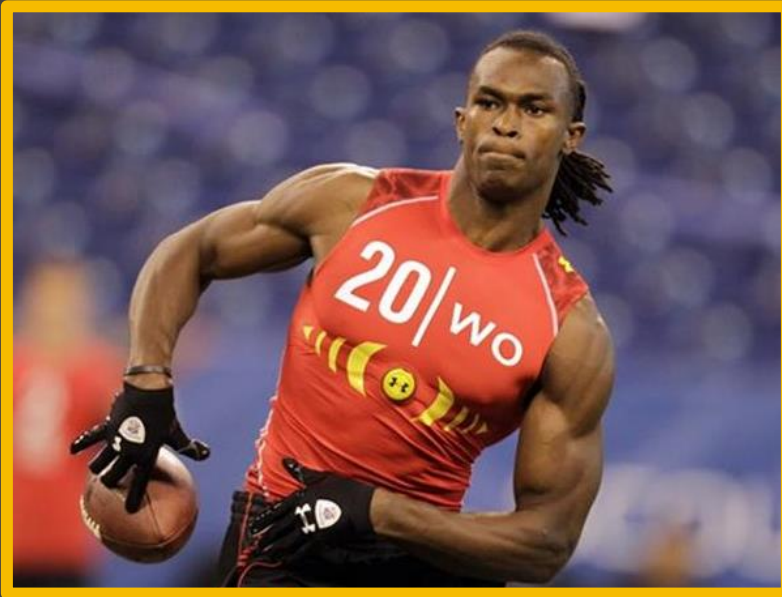


Wearables for **Sensing**



Wearables for **Sensing & Visualization**

Wearables & Sports



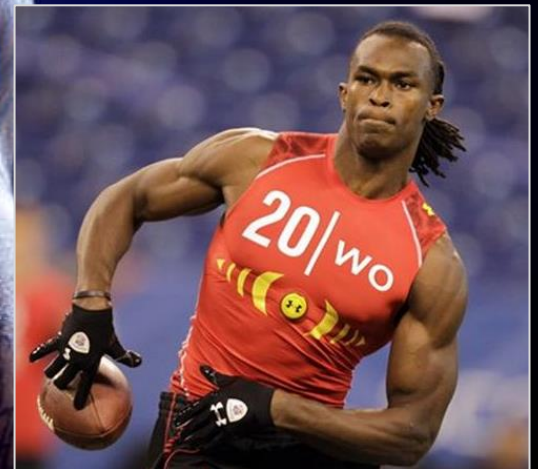
Wearables for **Sensing**



Wearables for **Sensing & Visualization**

Under Armour E39

Real-time athlete monitoring



Adidas miCoach Elite

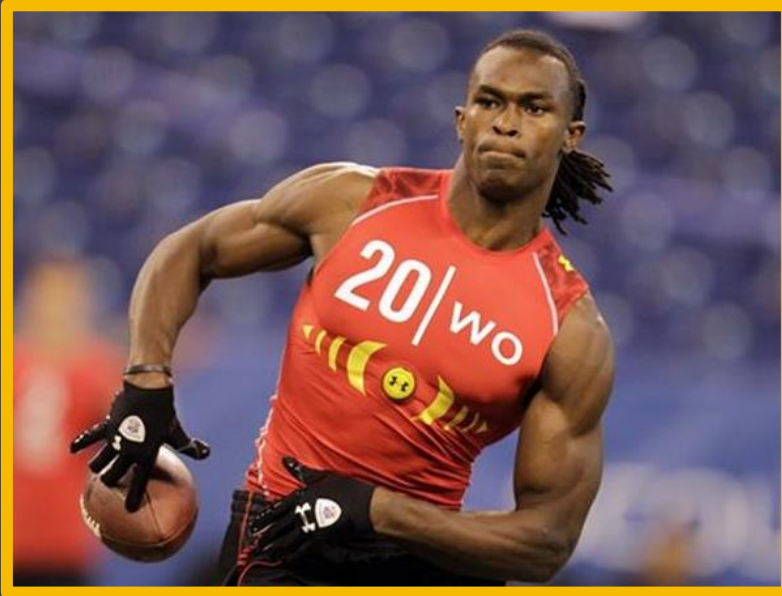
Real-time athlete monitoring



1449	VS	1971
811	VS	275
884	VS	2381



Wearables & Sports

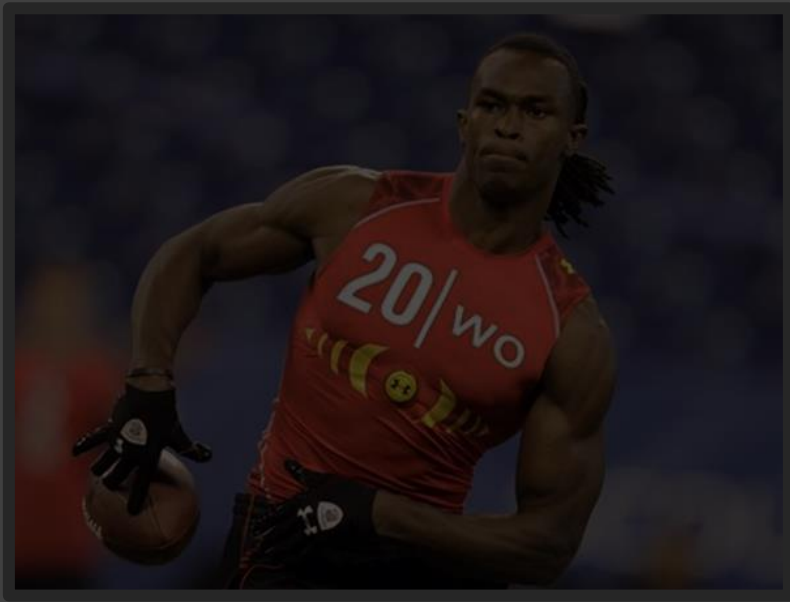


Wearables for **Sensing**



Wearables for **Sensing & Visualization**

Wearables & Sports



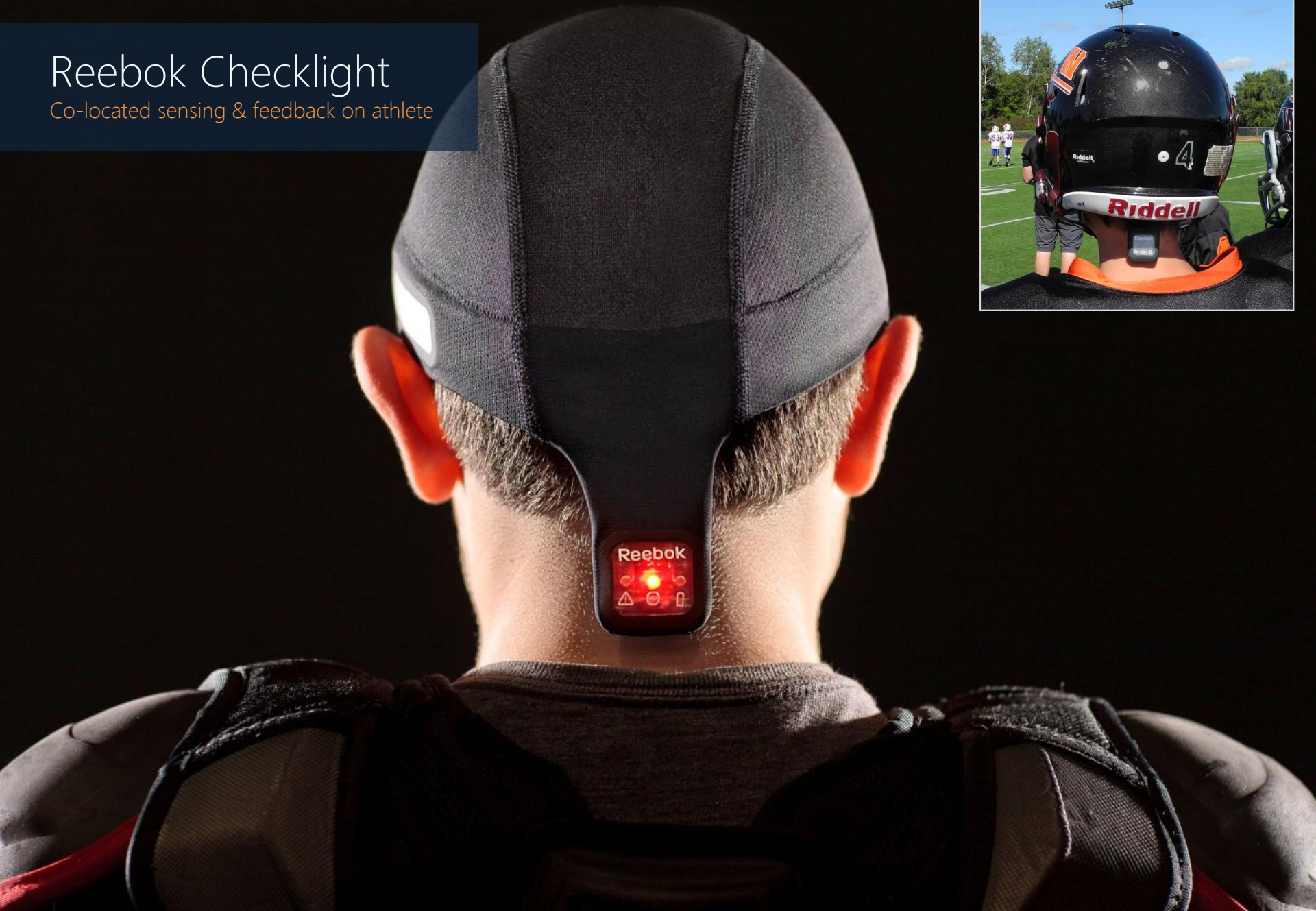
Wearables for Sensing



Wearables for **Sensing & Visualization**

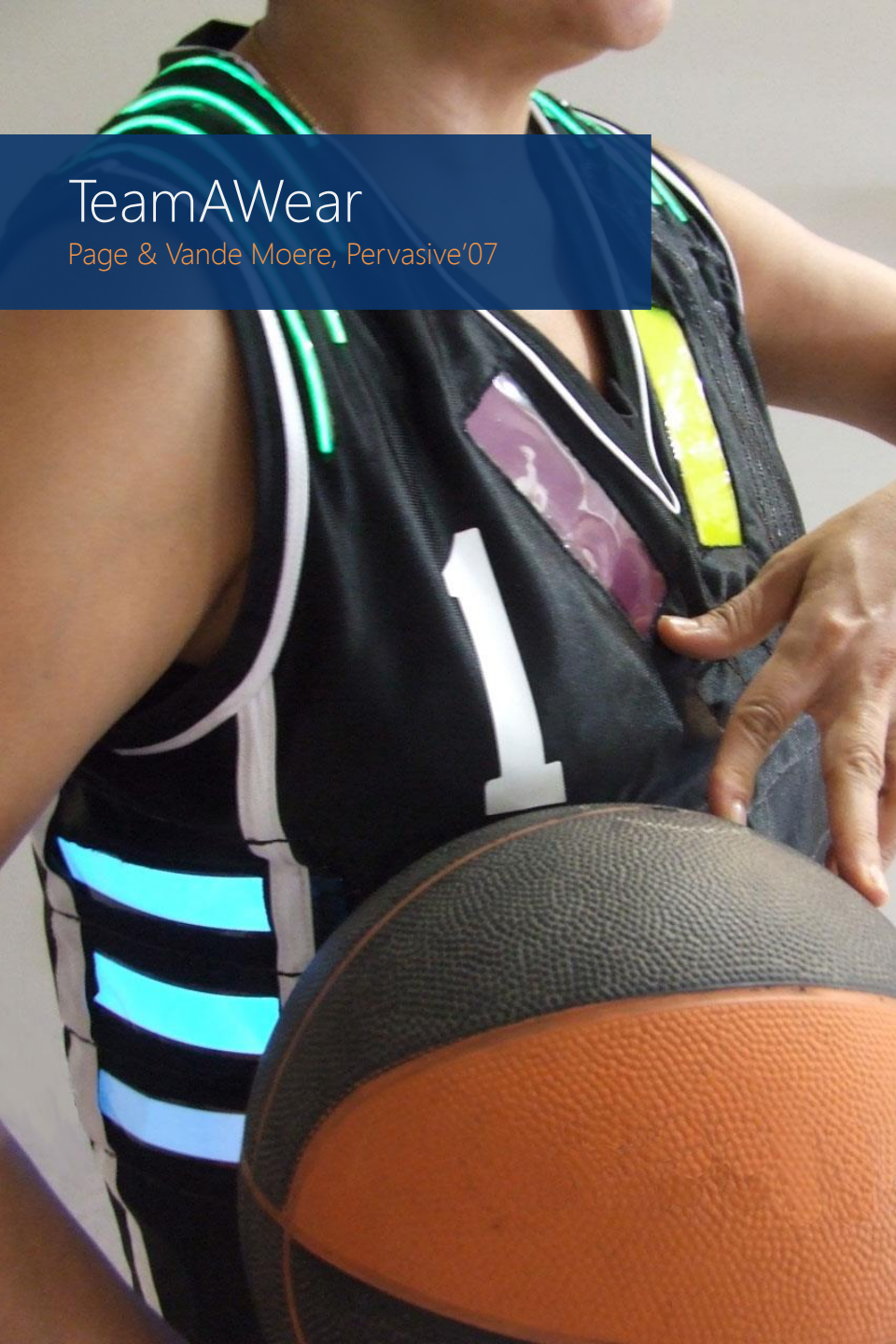
Reebok Checklight

Co-located sensing & feedback on athlete



TeamAWear

Page & Vande Moere, Pervasive'07



SFF: DESIGN AND EVALUATION PROCESS

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E**

SFF: DESIGN AND EVALUATION PROCESS

Ideation &
Lo-Fi Proto.

Parallel Prototyping
3 Designs

Refine
Final Design

Field Study of 10
Running Groups

2 Race
Studies

Informal Pilot Studies

Final
Pilots

SFF: DESIGN AND EVALUATION PROCESS

Ideation &
Lo-Fi Proto.

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Pilots

DESIGN GOALS



Comfort



Robustness



Display Content

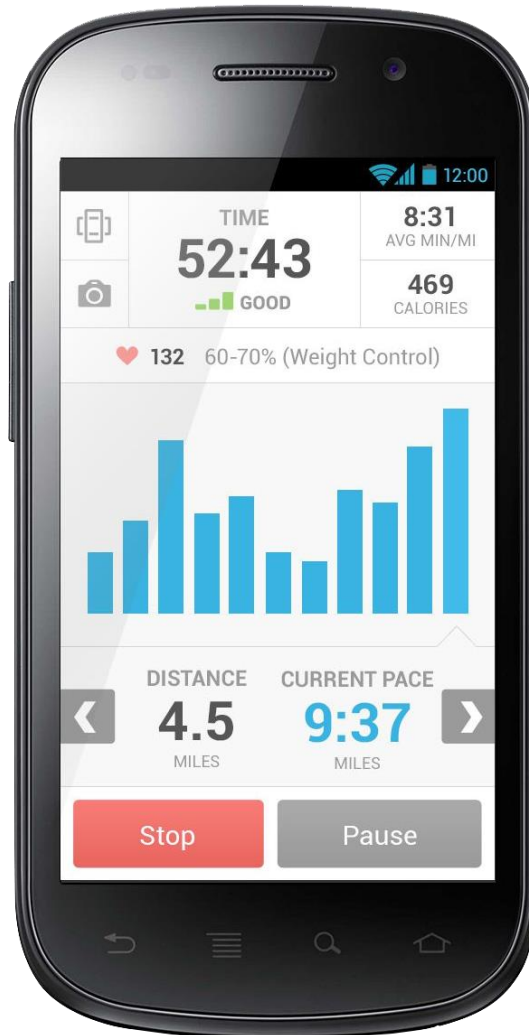


User Experience

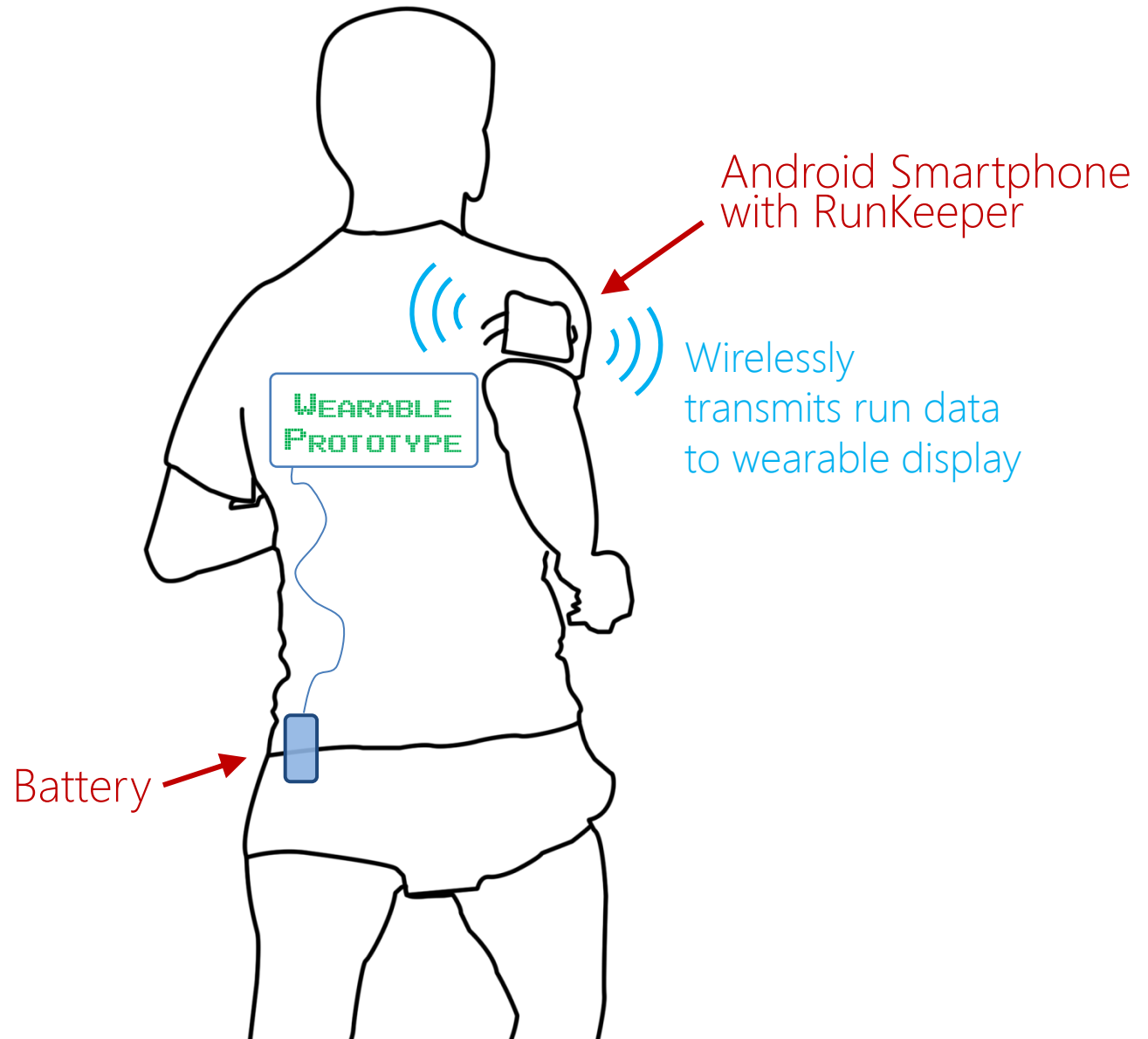


SFF: SYSTEM OVERVIEW

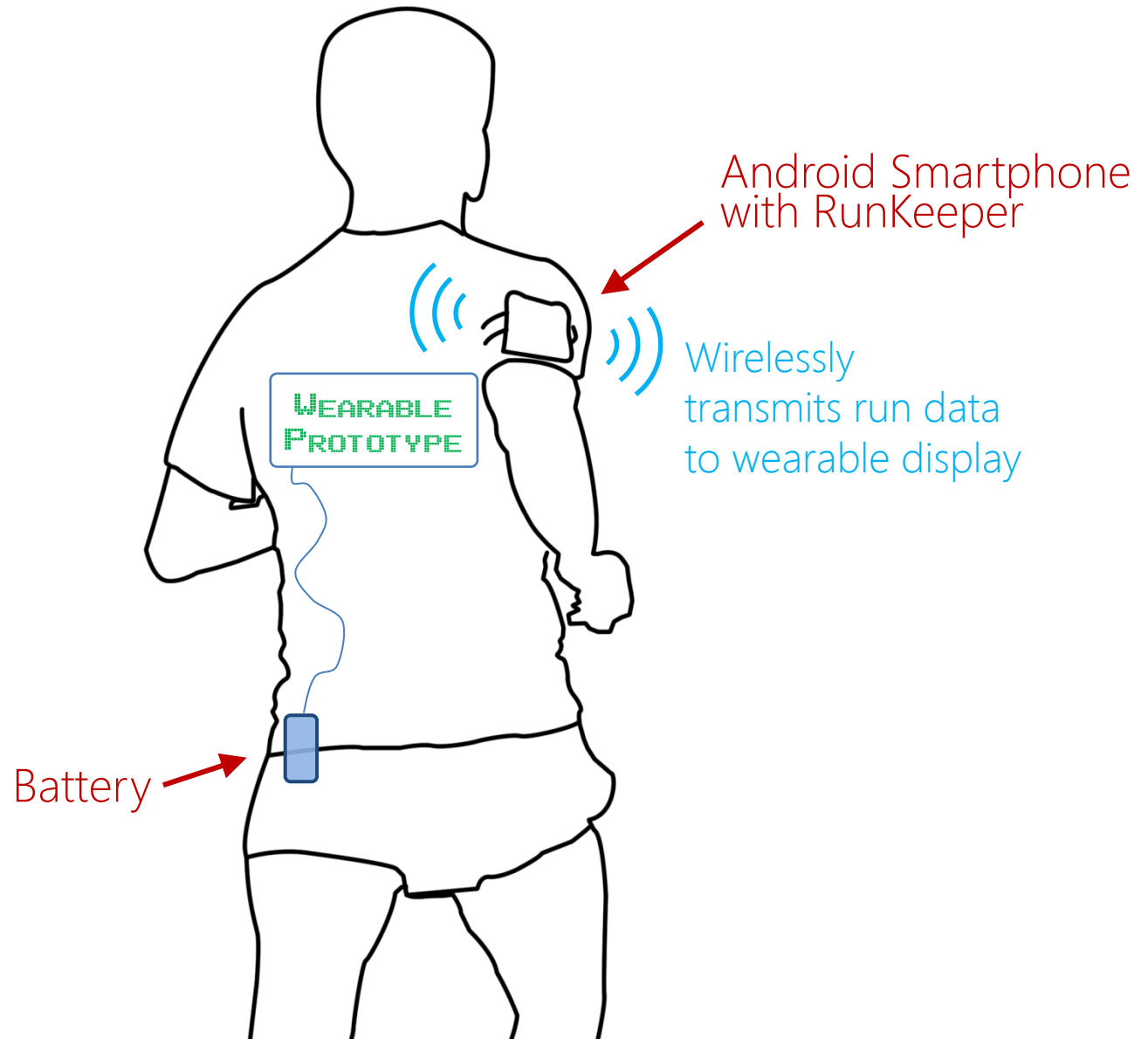
RunKeeper



SFF: SYSTEM OVERVIEW



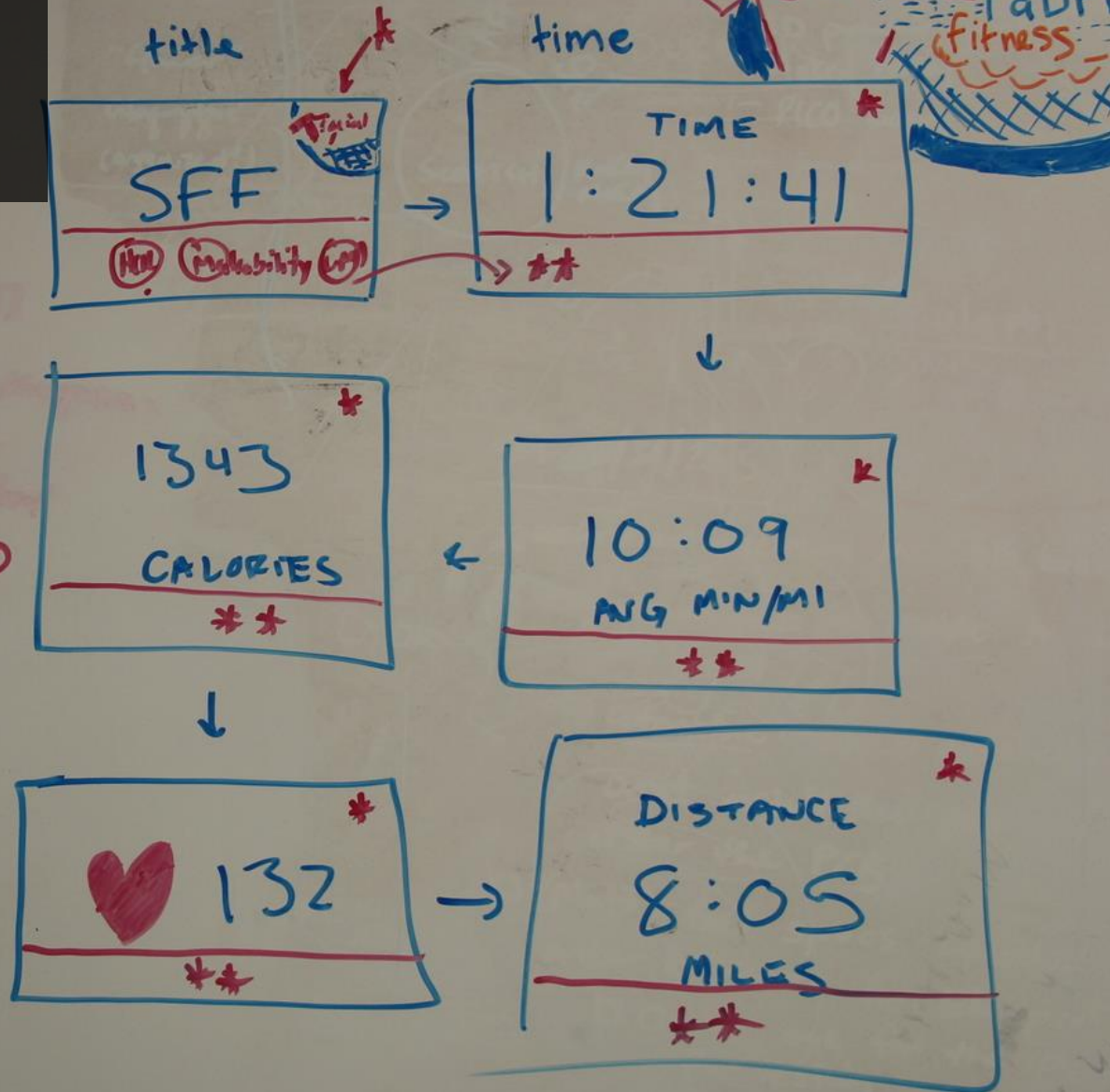
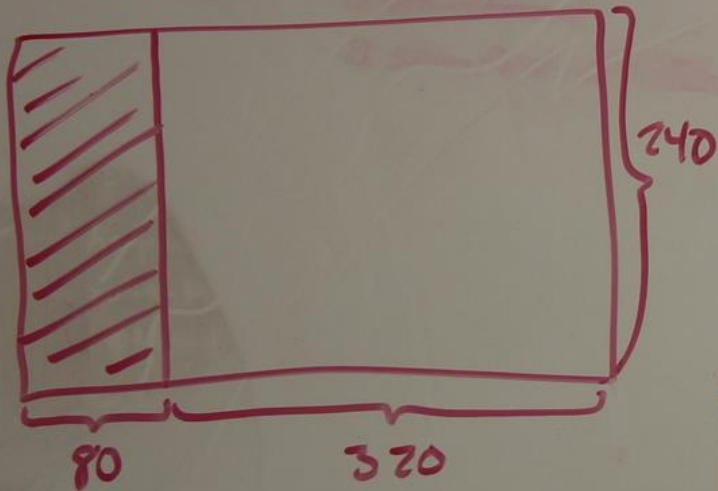
SFF: SYSTEM OVERVIEW



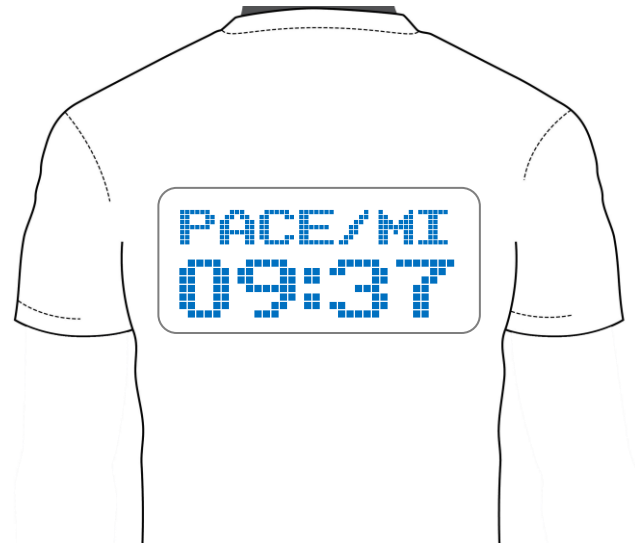
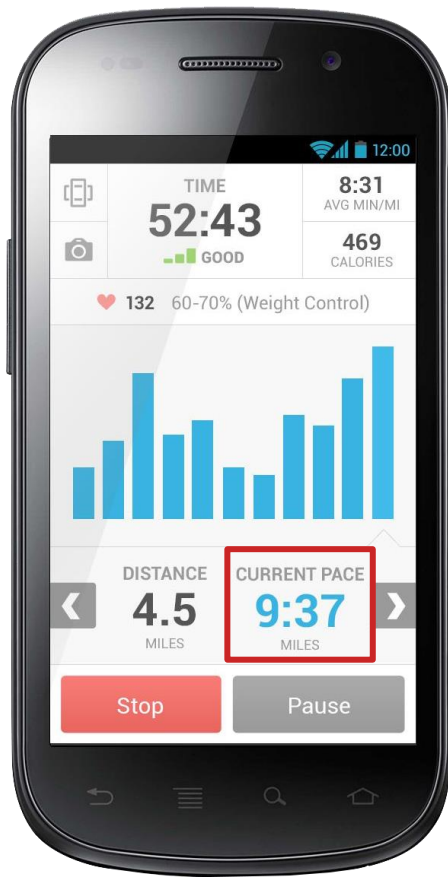
Designing the Visual Content

Glanceable & Easy-to-understand

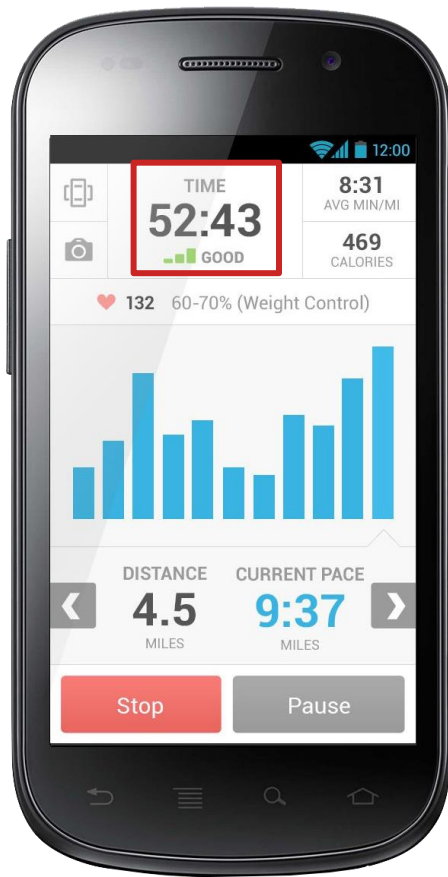
- calcs. burned
- time



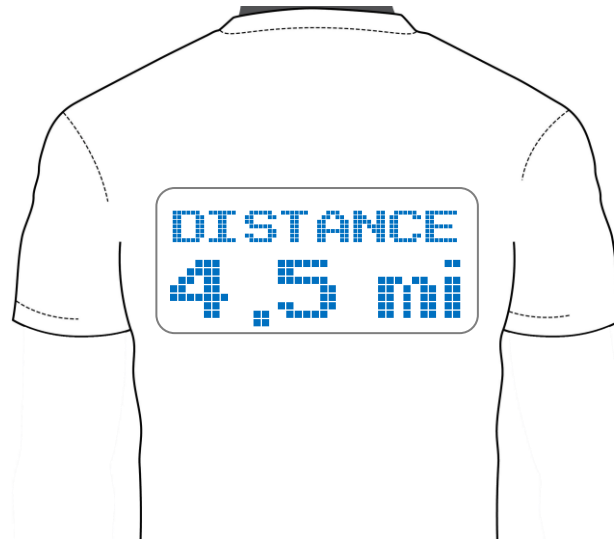
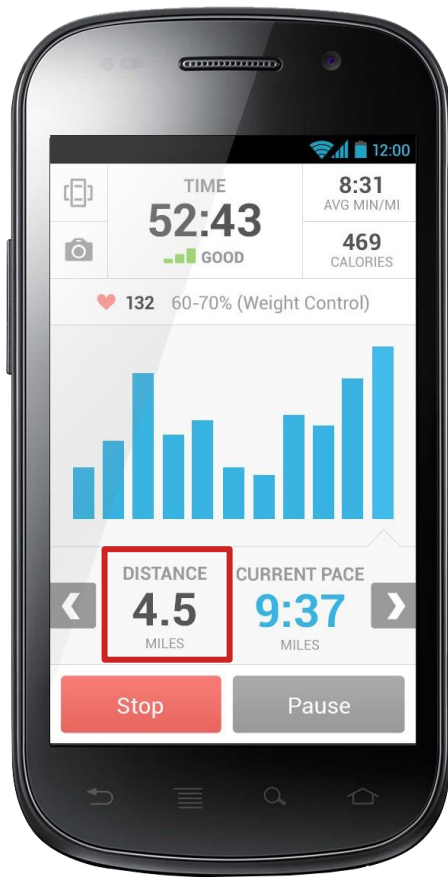
SFF: PRIMARY VISUALIZATIONS



SFF: PRIMARY VISUALIZATIONS

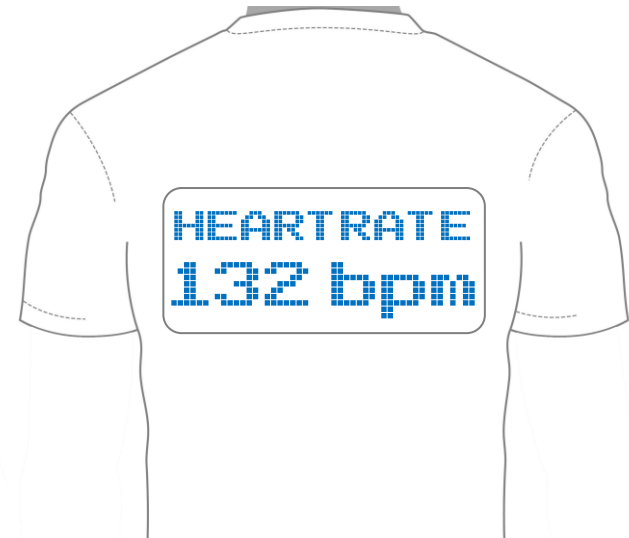
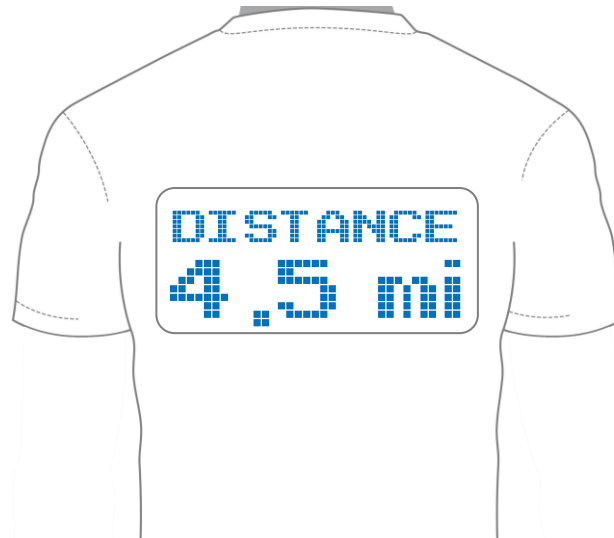
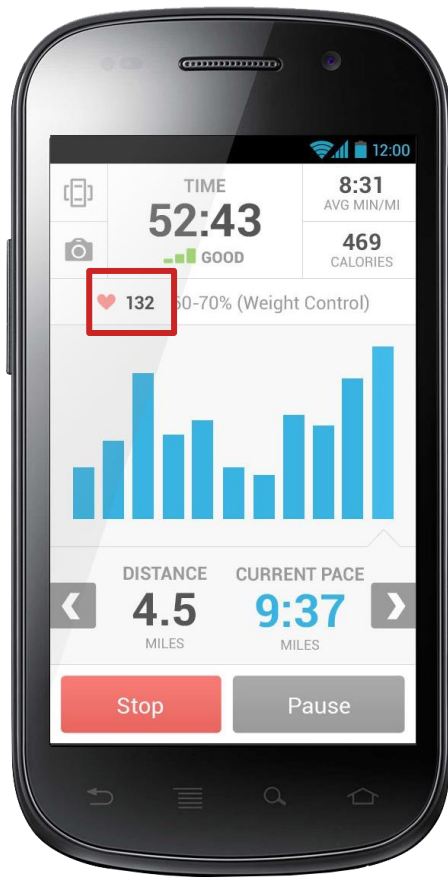


SFF: PRIMARY VISUALIZATIONS



Although RunKeeper tracks a single user, these **measures are shared** across the running group as they run together.

SFF: PRIMARY VISUALIZATIONS



Comfort

Low-Fidelity Prototypes



SFF: DESIGN AND EVALUATION PROCESS

Ideation &
Lo-Fi Proto.

Parallel Prototyping
3 Designs

Refine
Final Design

Field Study of 10
Running Groups

2 Race
Studies

Informal Pilot Studies

Final
Pilots

SFF: DESIGN AND EVALUATION PROCESS

Ideation &
Lo-Fi Proto.

Parallel Prototyping
3 Designs

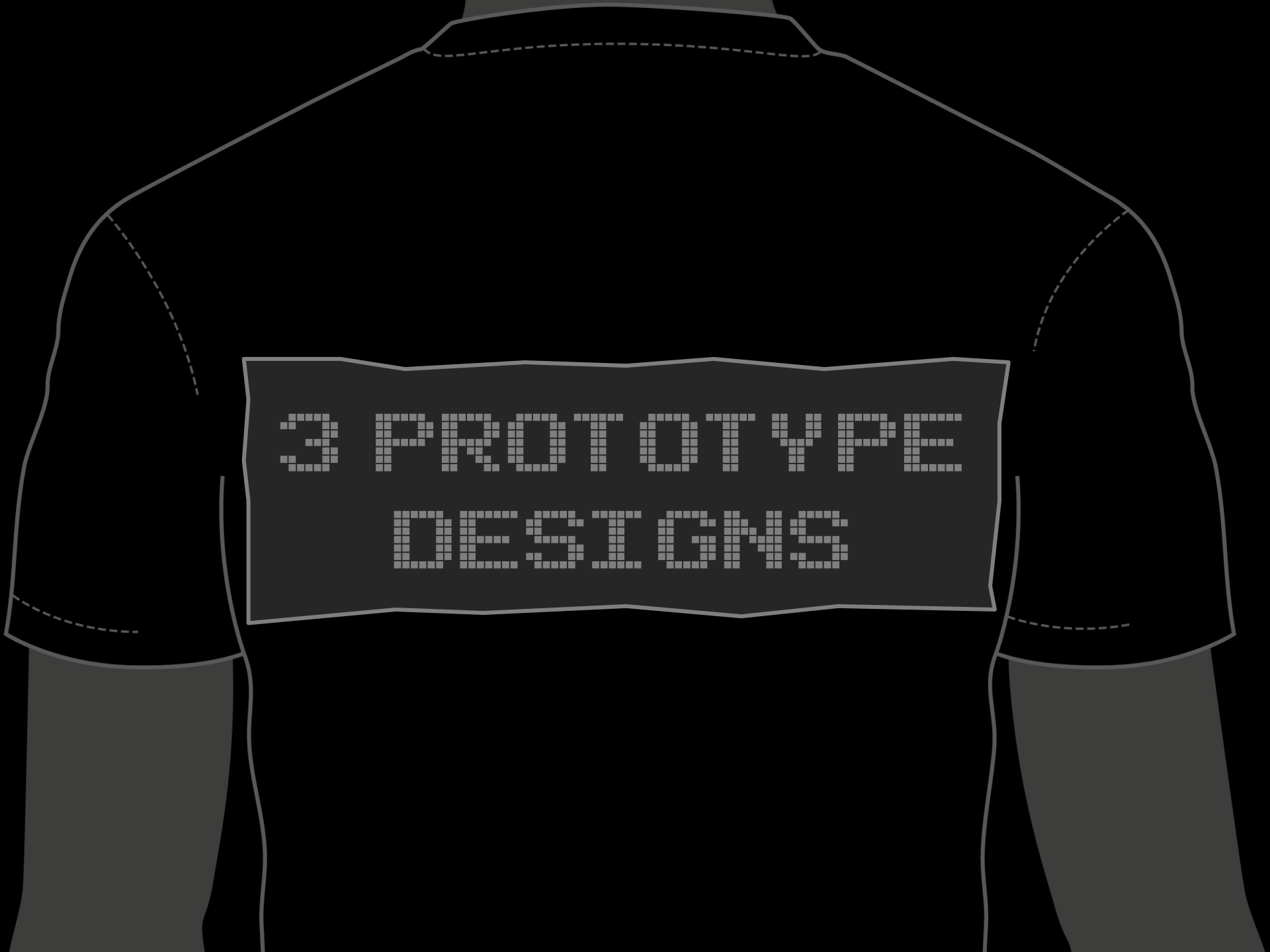
Refine
Final Design

Field Study of 10
Running Groups

2 Race
Studies

Informal Pilot Studies

Final
Pilots



3 PROTOTYPE
DESIGNS

Prototype #1

Custom LED Matrix Display



Prototype #2

Electronic Ink Display



Prototype #3

Erogear LED Matrix Display



Prototype #1

Custom LED Matrix Display



Prototype #2

Electronic Ink Display



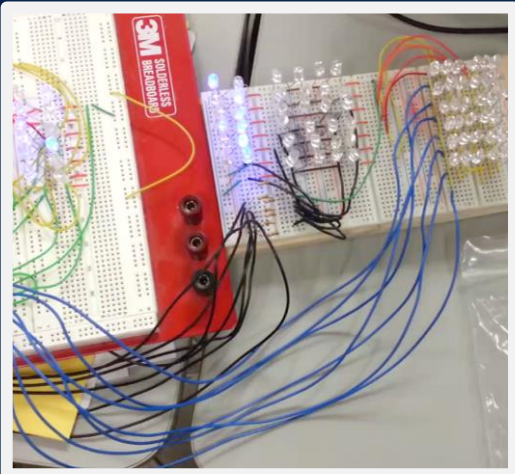
Prototype #3

Erogear LED Matrix Display

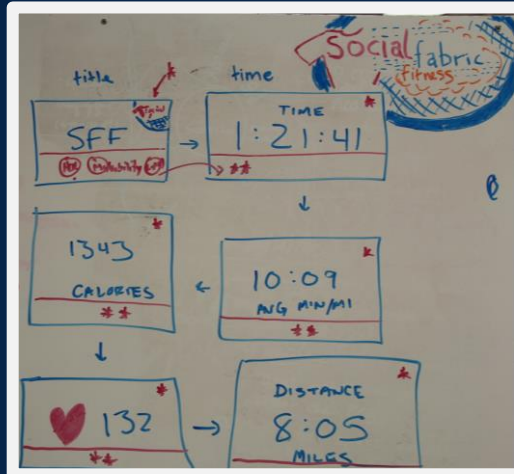


Prototype #1

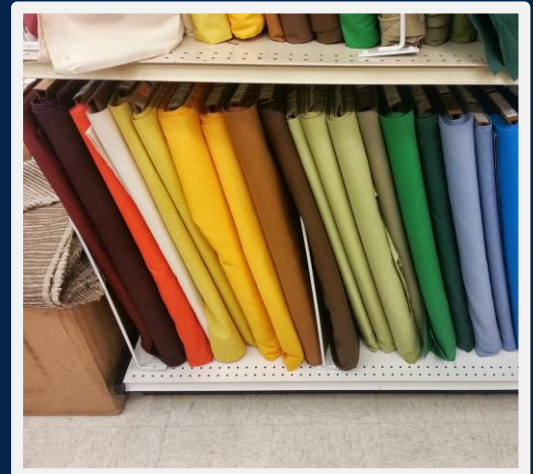
Three prototyping dimensions



Prototyping **Technology**



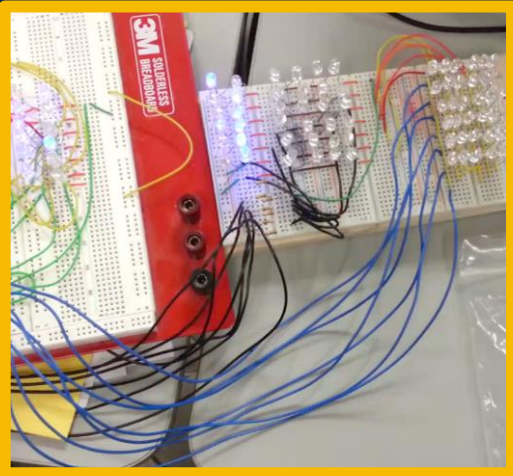
Prototyping **Visualization**



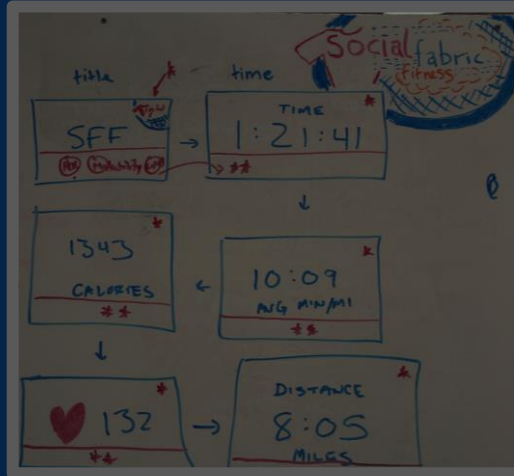
Prototyping **Materials**

Prototype #1

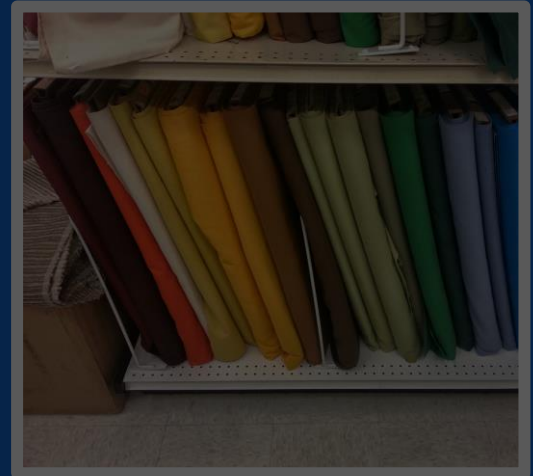
Three prototyping dimensions



Prototyping **Technology**



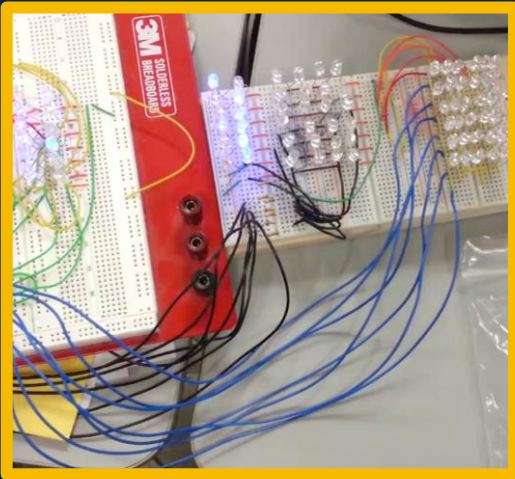
Prototyping **Visualization**



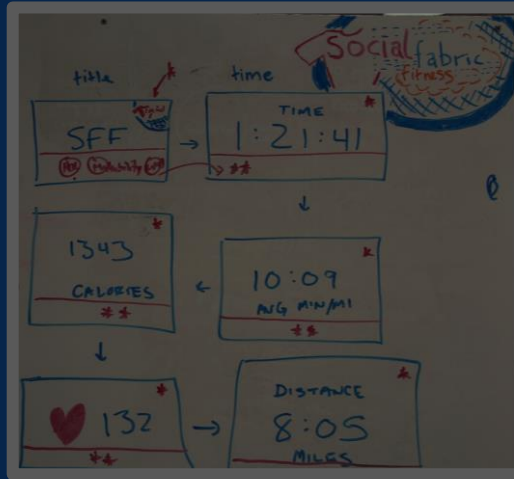
Prototyping **Materials**

Prototype #1

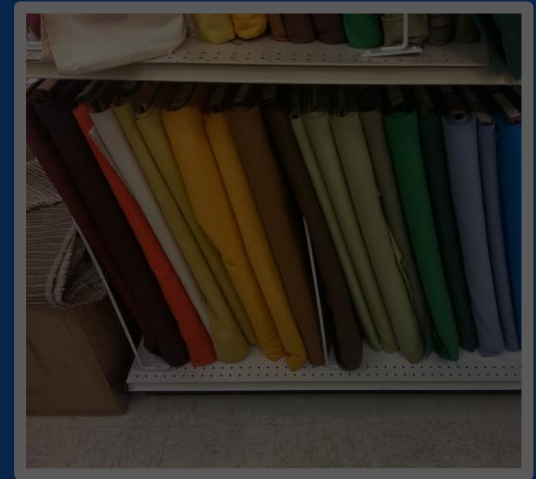
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**

1

Select MCU
Platform

2

Prototype
Circuit Designs

3

Build
Software

4

Layout
PCB

5

Manufacture
PCB

6

Test Final PCB
& Software

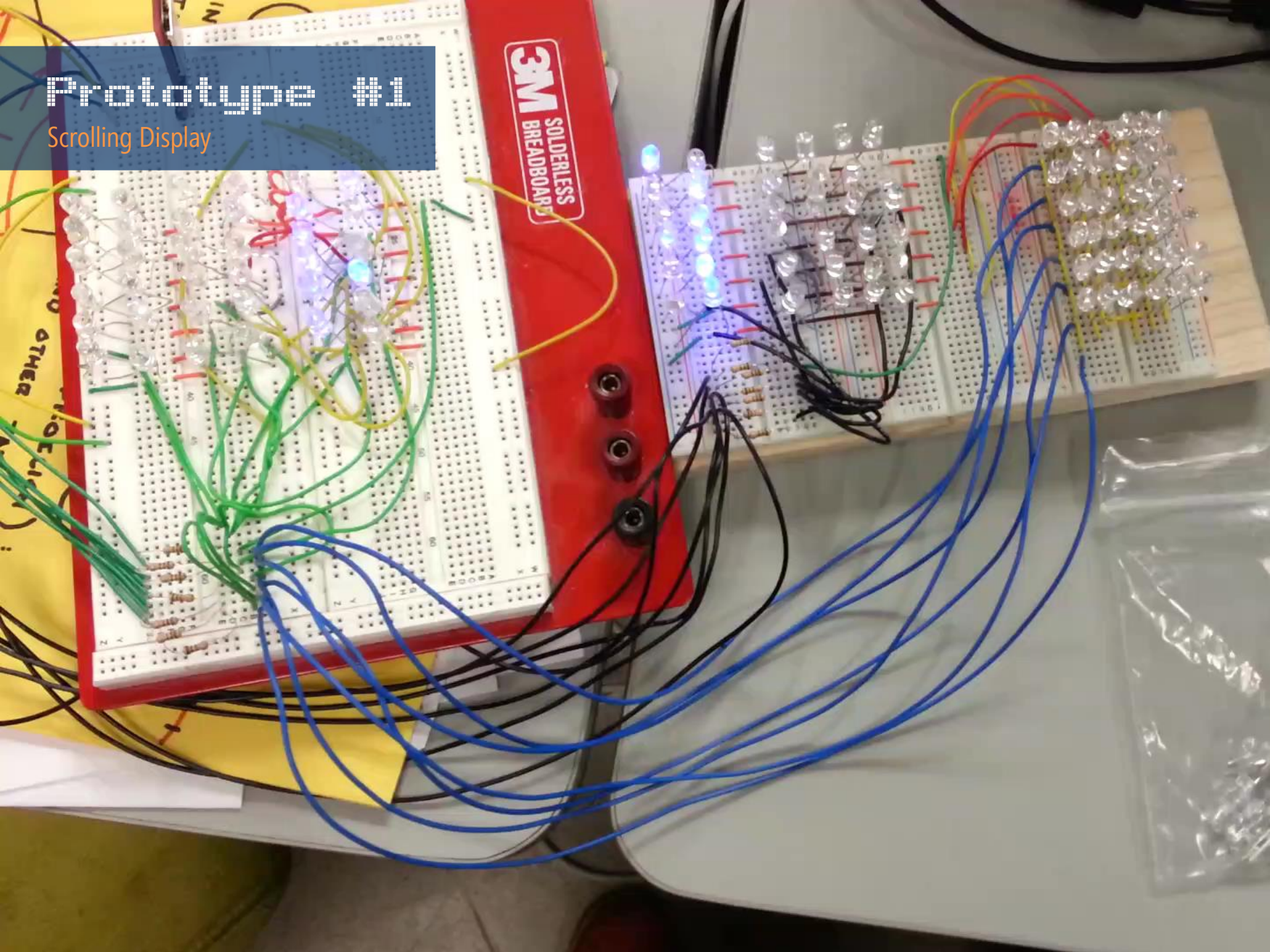
Prototype #1

Single Letter Display Test



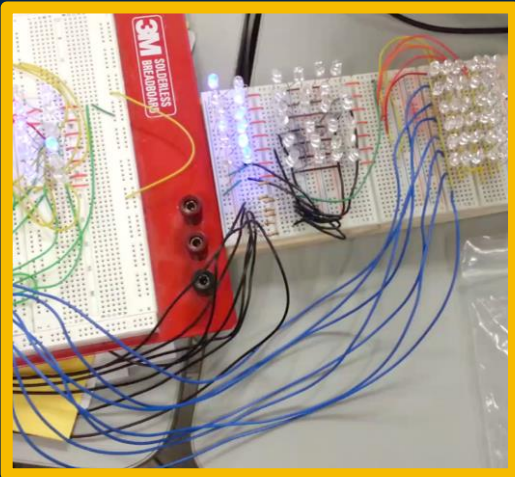
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Scrolling Display

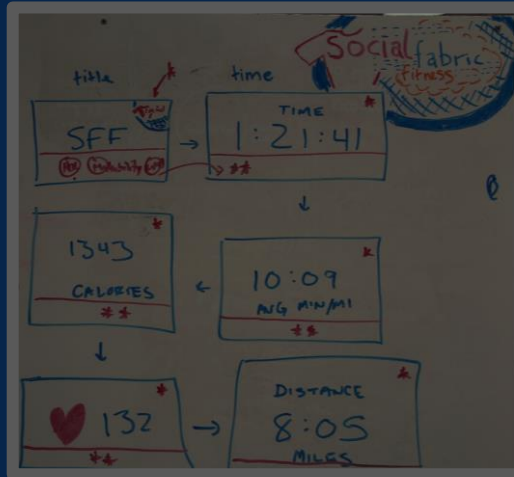


Prototype #1

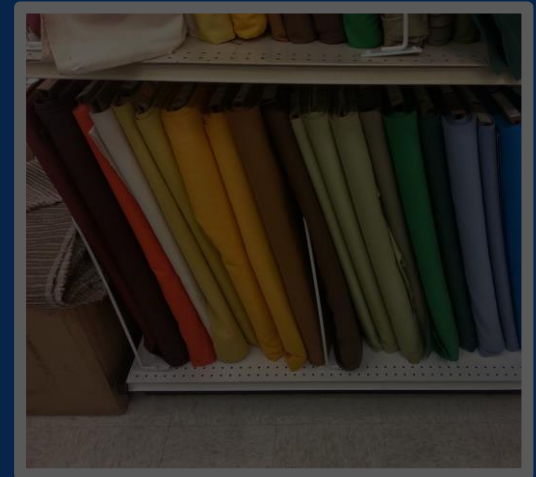
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**

1

Select MCU
Platform

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Circuit Designs

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Software

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PCB

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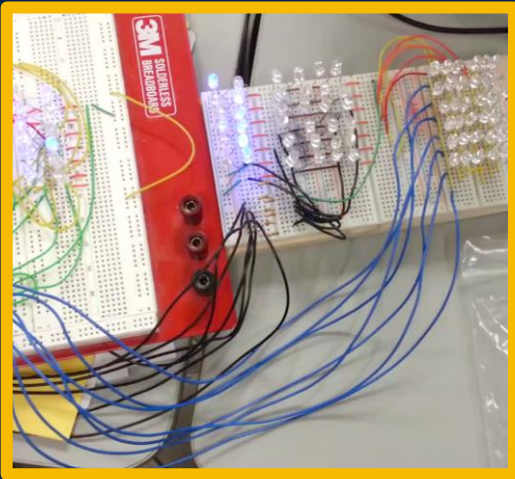
Manufacture
PCB

6

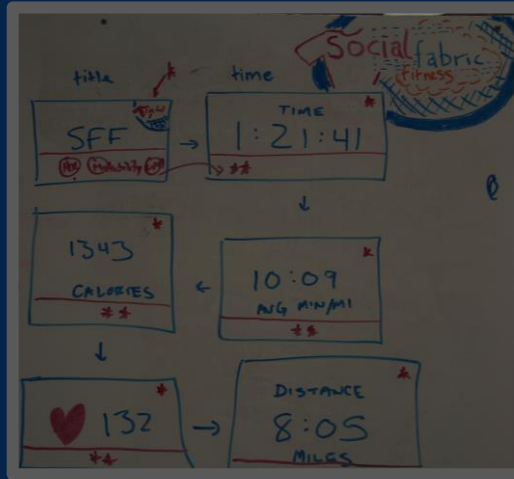
Test Final PCB
& Software

Prototype #1

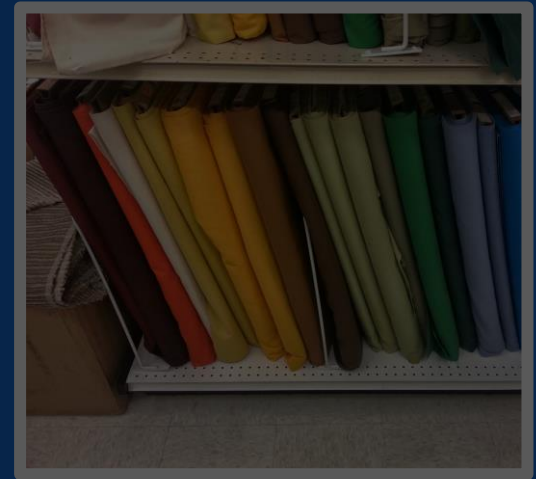
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**

1

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Platform

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PCB

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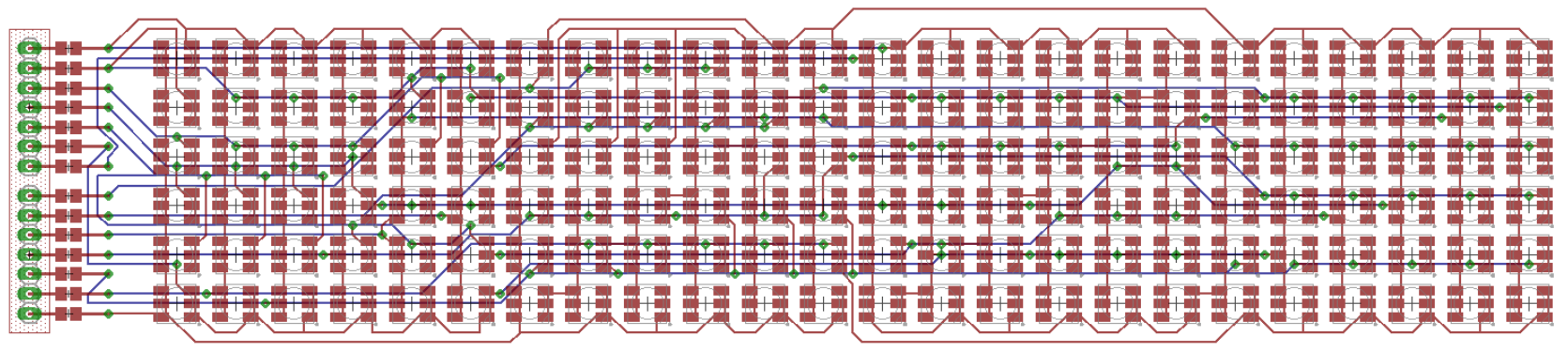
Test Final PCB
& Software

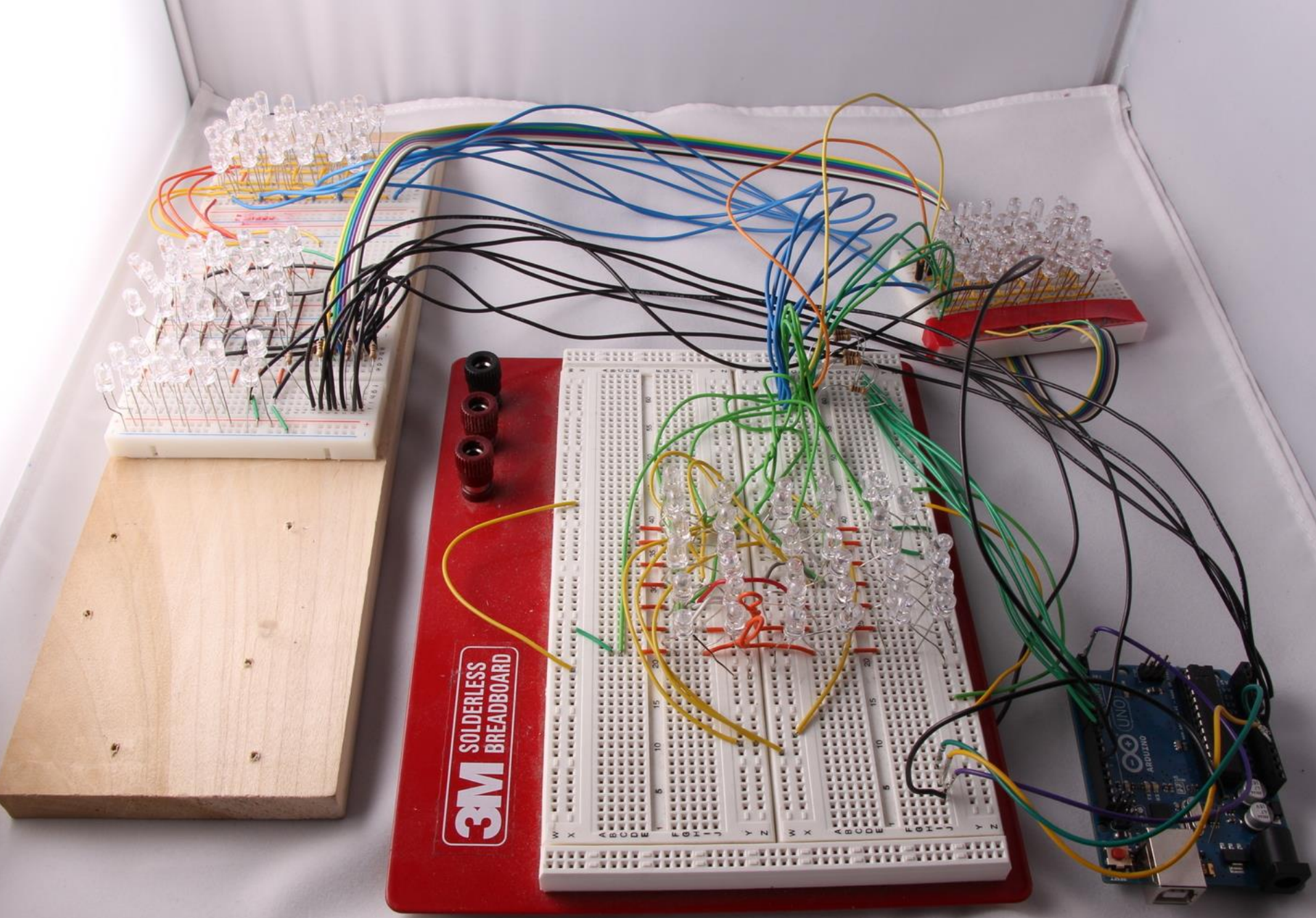
File Edit Draw View Tools Library Options Window Help

0.05 inch (8.25 3.55) |

Prototype #1

Prepare PCB Schematic





Manufactured at PCBUniverse.com and pick-and-place performed by Tristate Electronics

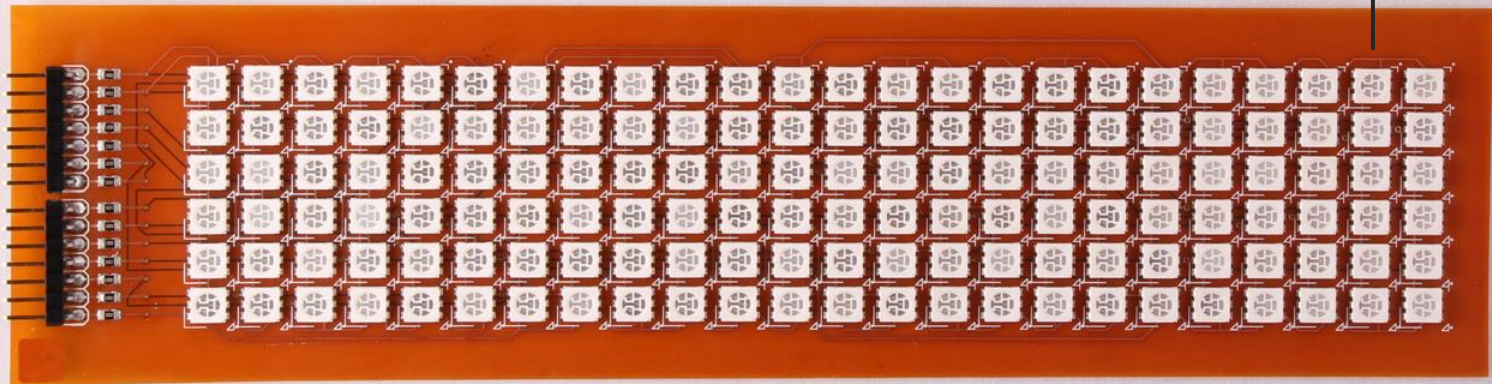
Prototype #1

Manufactured Flexible PCB

Flexible PCB

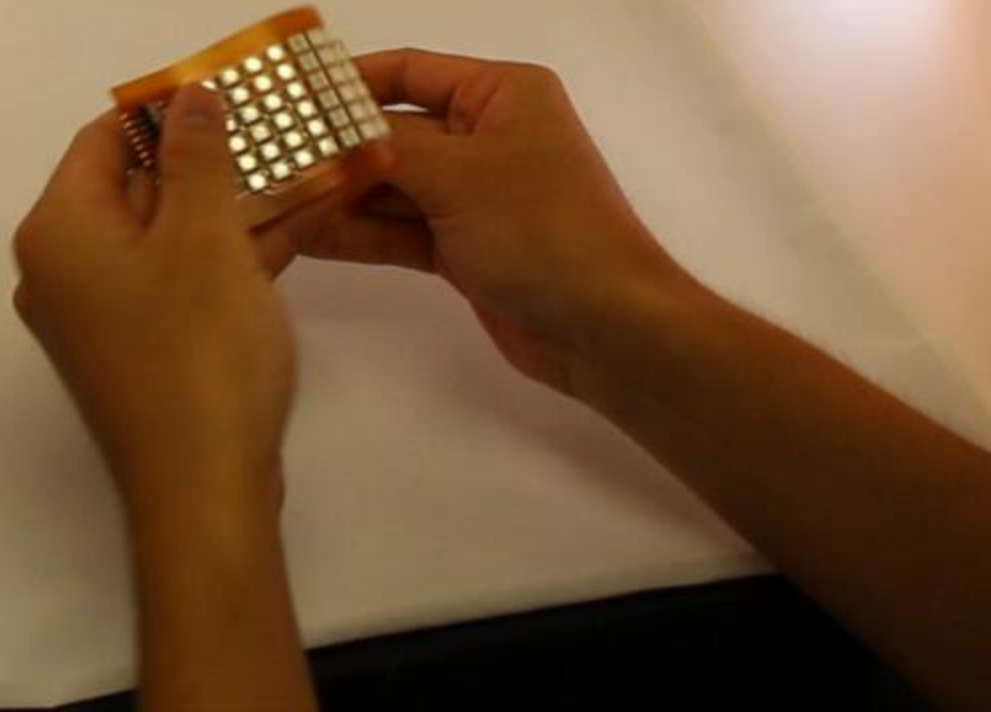
24 x 6 Matrix

Green or Blue LEDs



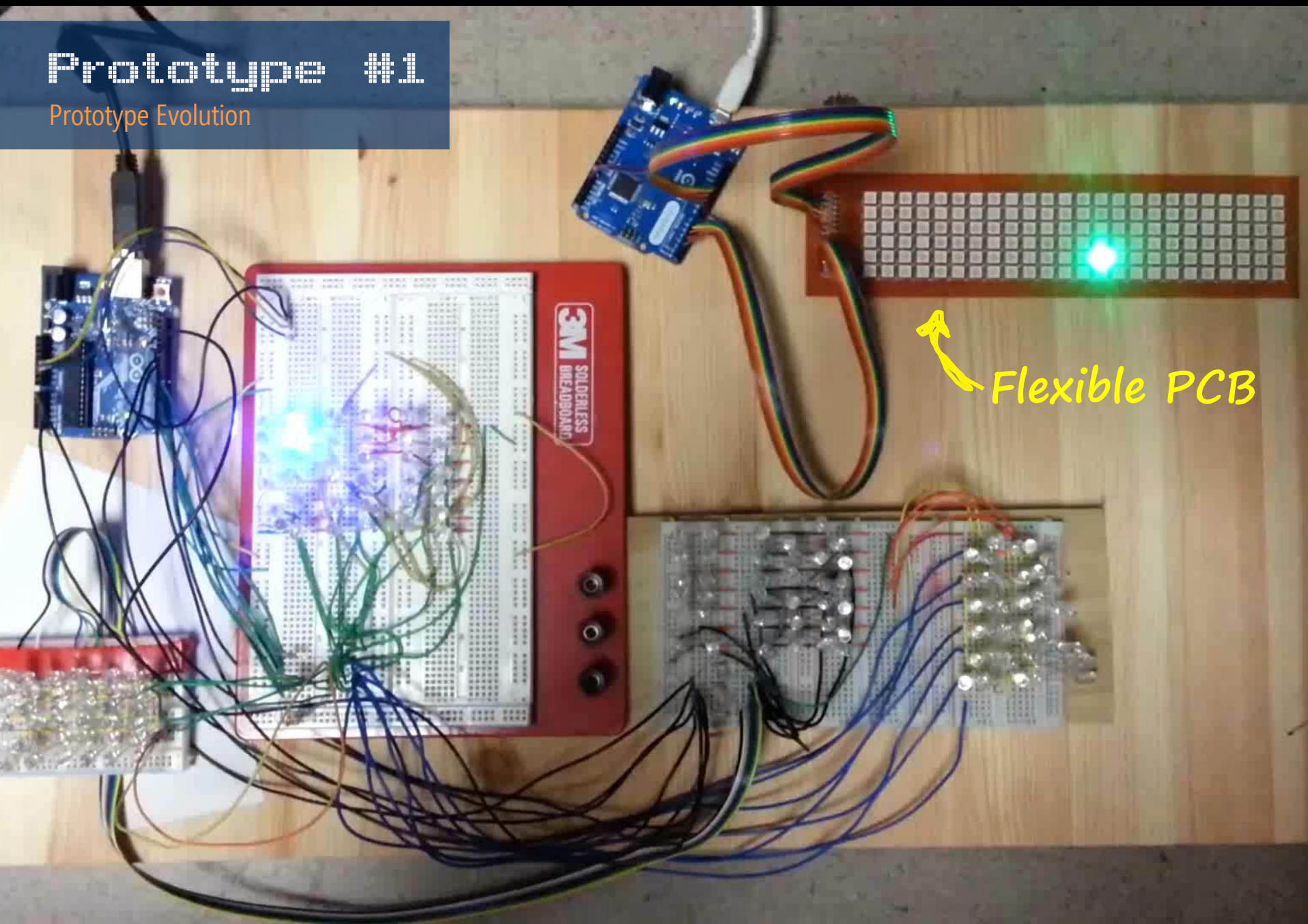
Prototype #1

Flexible PCB



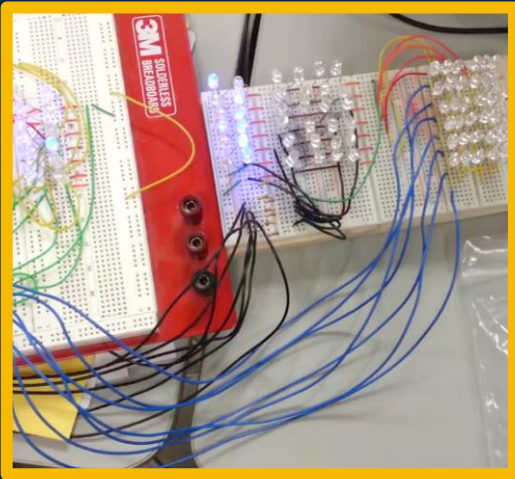
Prototype #1

Prototype Evolution

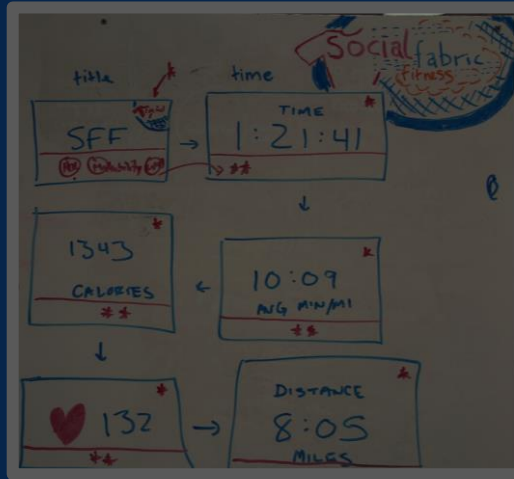


Prototype #1

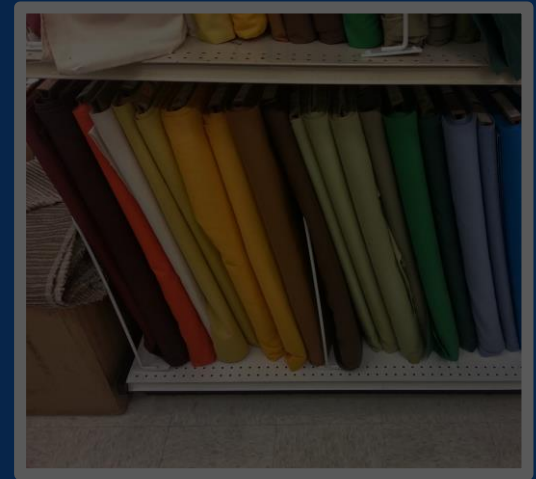
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**

1

Select MCU
Platform

2

Prototype
Circuit Designs

3

Build
Software

4

Layout
PCB

5

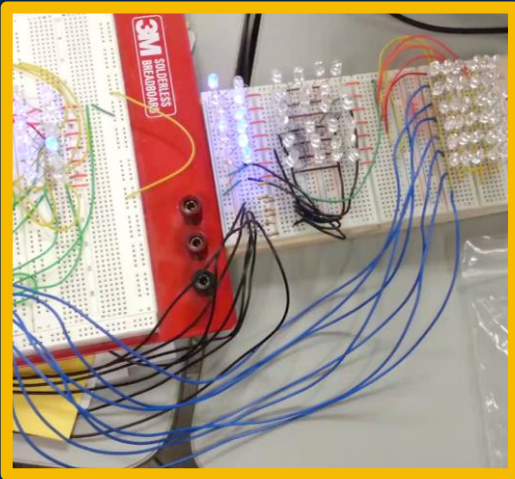
Manufacture
PCB

6

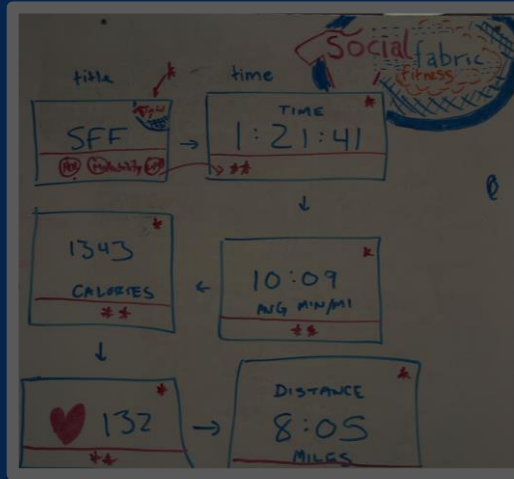
Test Final PCB
& Software

Prototype #1

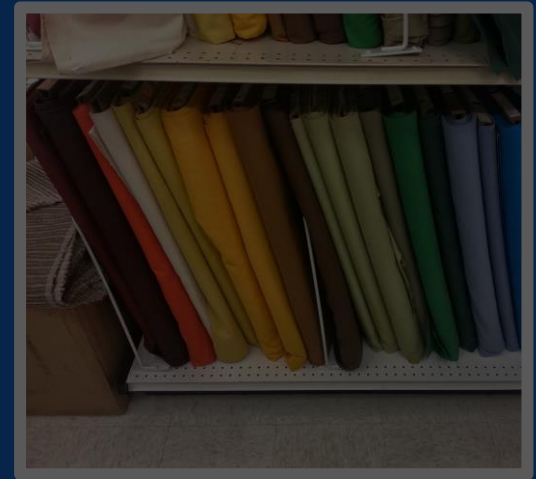
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**



Select MCU
Platform



Prototype
Circuit Designs



Build
Software



Layout
PCB



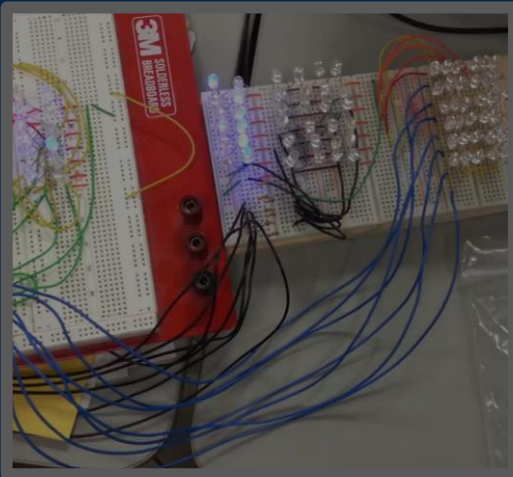
Manufacture
PCB



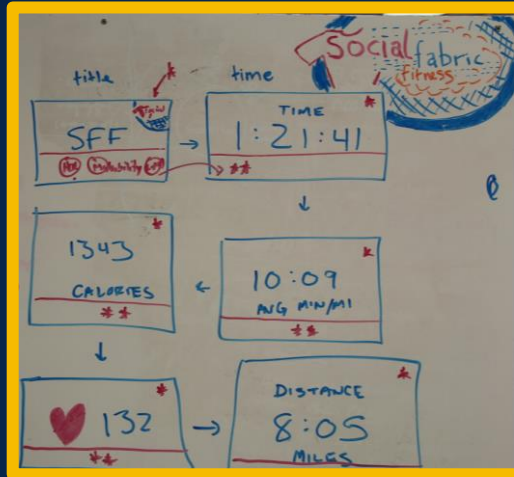
Test Final PCB
& Software

Prototype #1

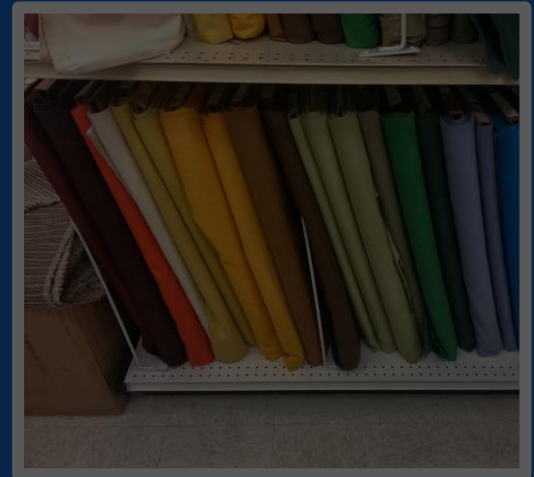
Three prototyping dimensions



Prototyping **Technology**



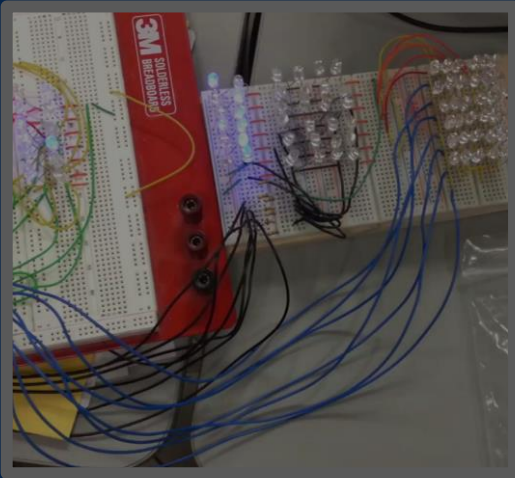
Prototyping **Visualization**



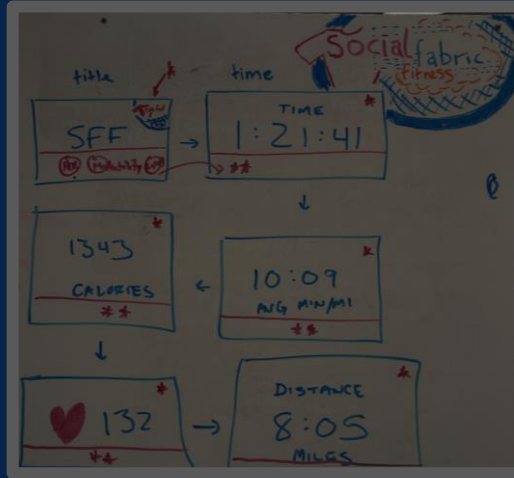
Prototyping **Materials**

Prototype #1

Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



Prototyping **Materials**

JO-ANN

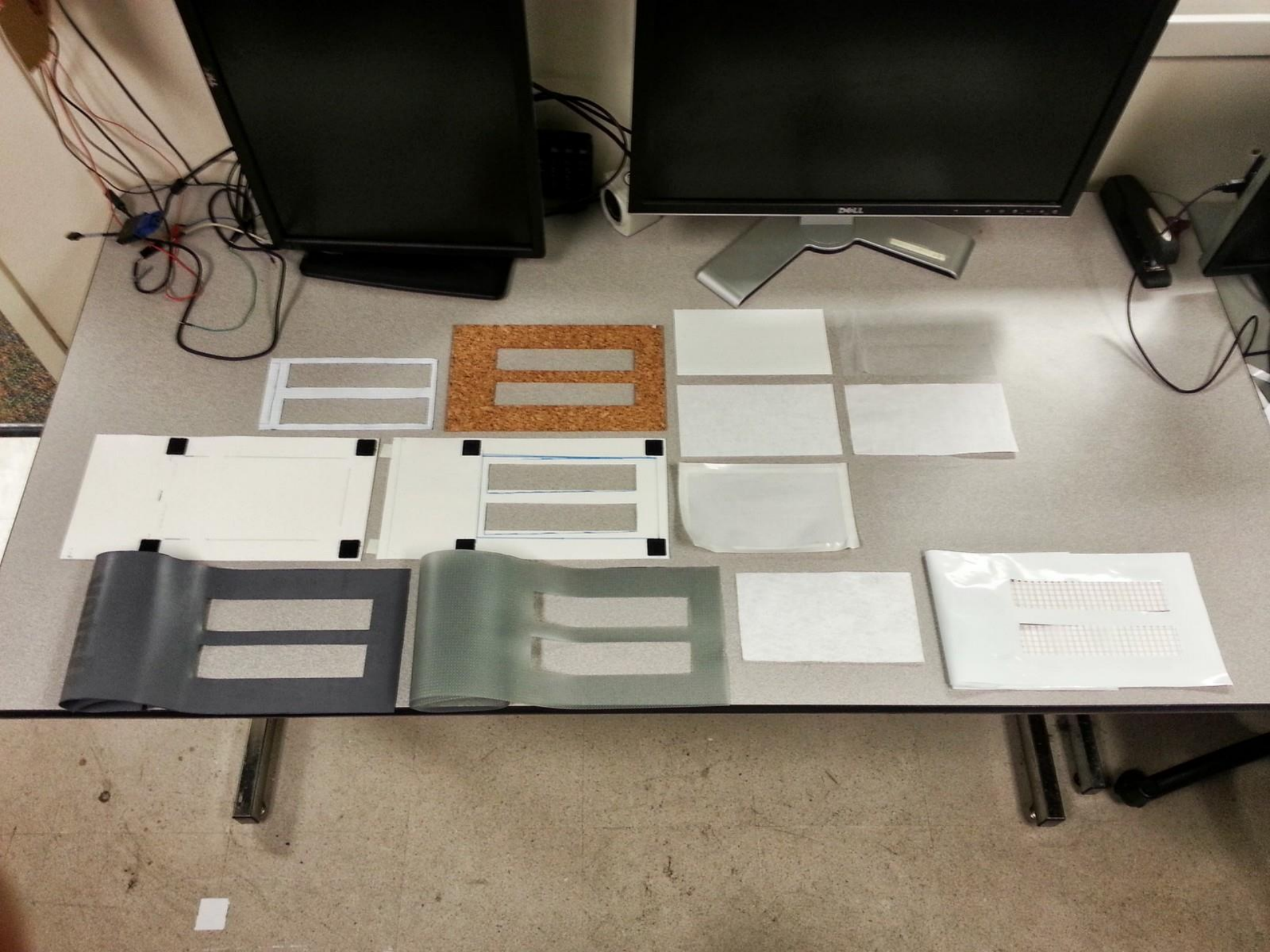
fabrics and crafts

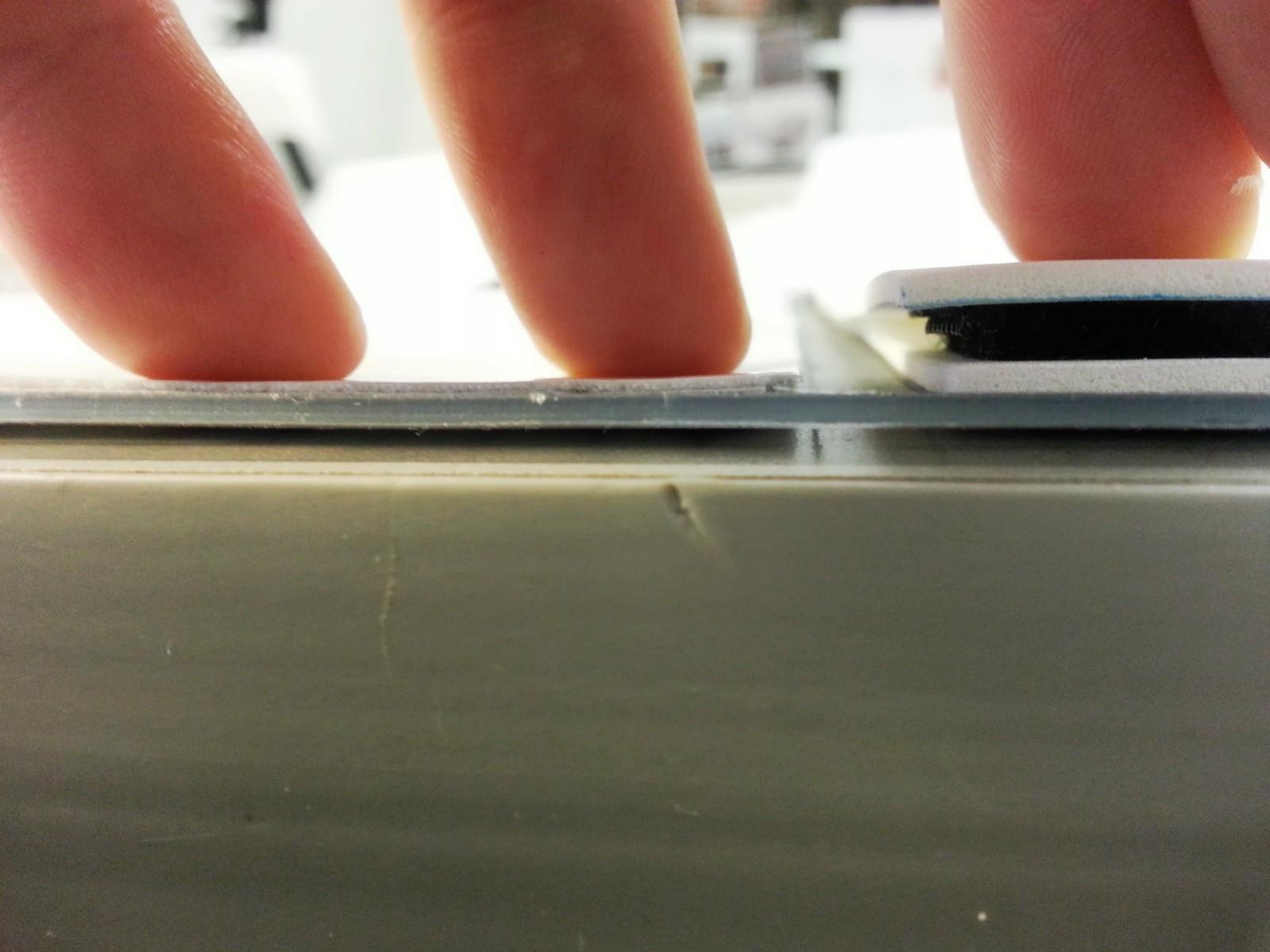
NO
PARKING
FIRE
LAW

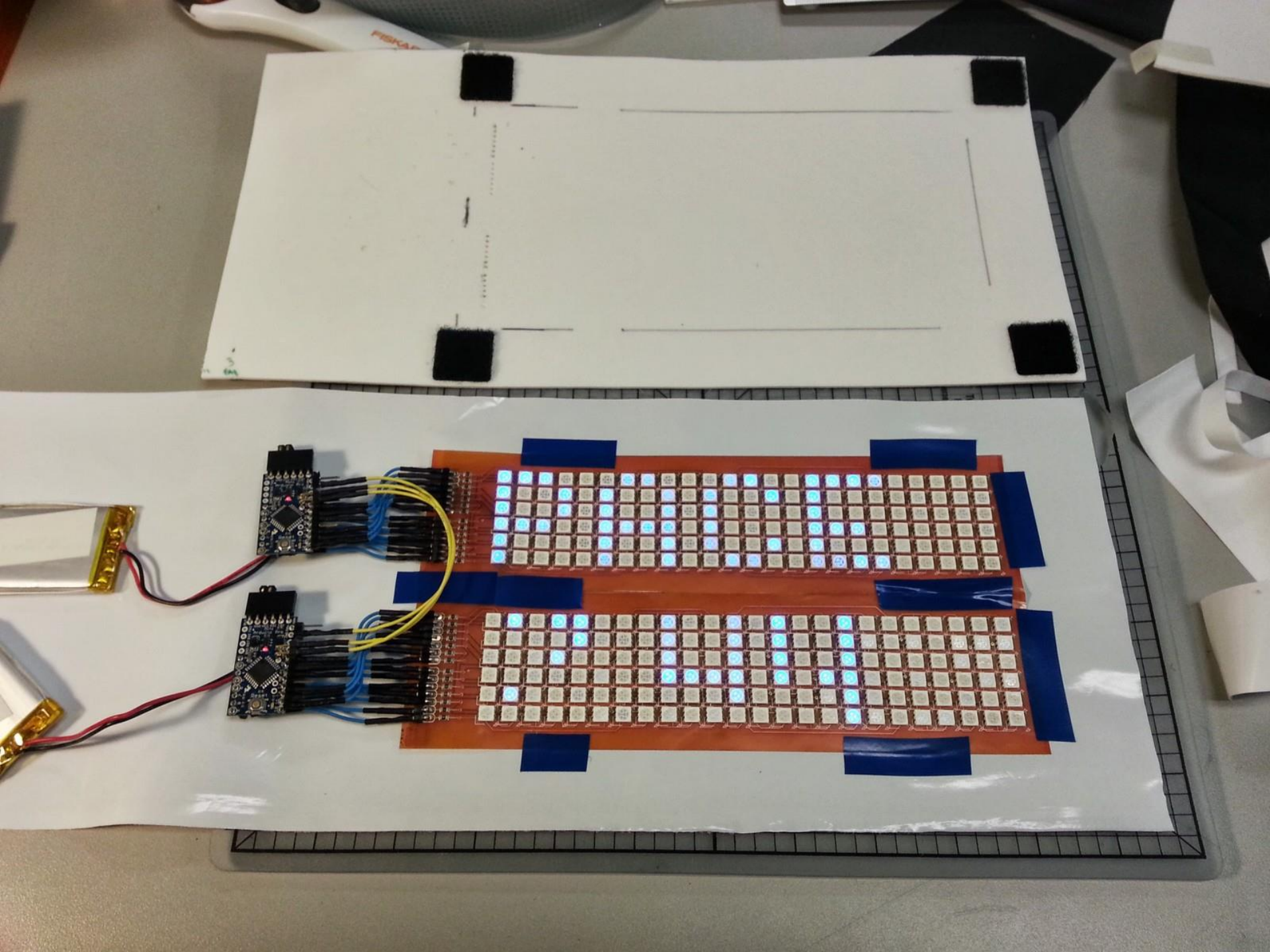
OK TIRE

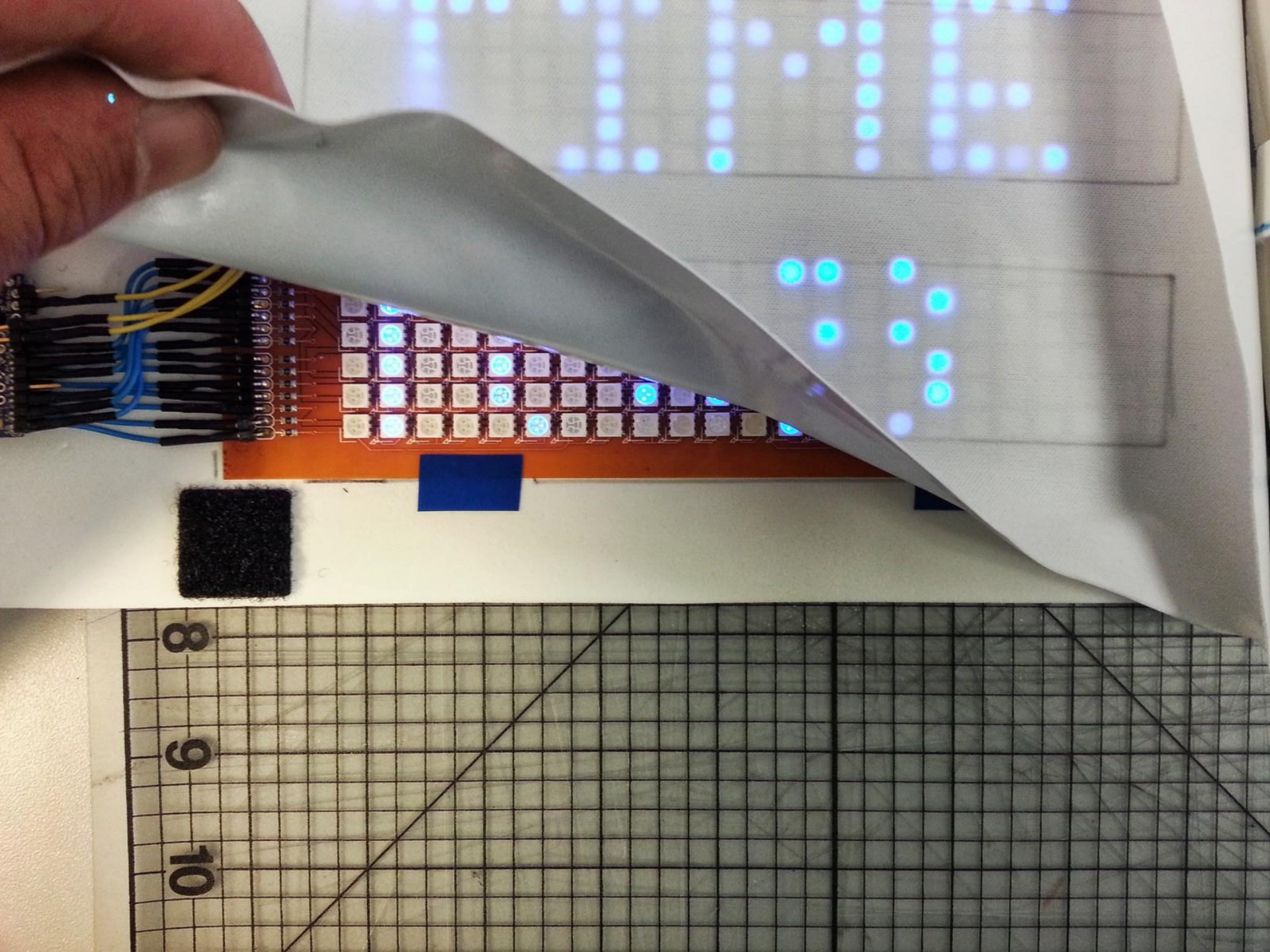






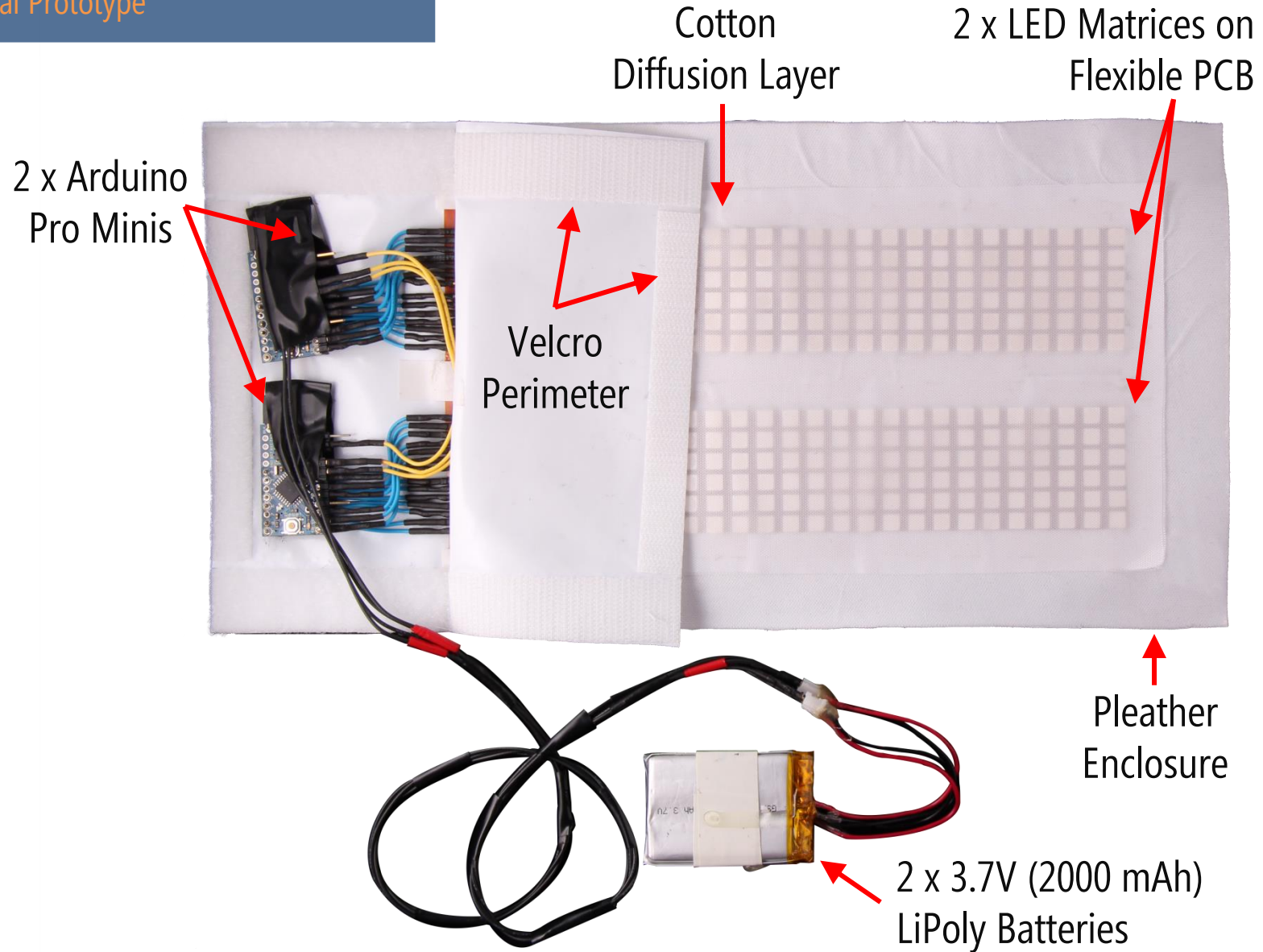




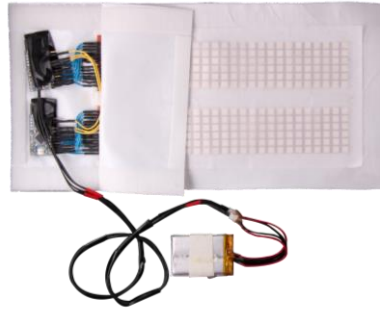


Prototype #1

Final Prototype



SFF: THREE PROTOTYPES



Prototype #1

As a comparison:
iPhone 4S = 140 g



Prototype #1

Custom LED Matrix Display



Prototype #2

Electronic Ink Display



Prototype #3

Erogear LED Matrix Display



Prototype #2

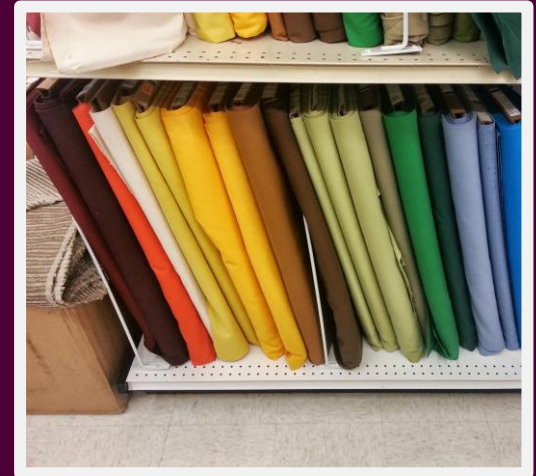
Three steps



Find **Manufacturer**



Prototyping **Software**



Prototyping **Materials**



YOU'RE LOOKING AT THE

WORLD'S 1ST

PRODUCTION-READY

PLASTIC DISPLAY

PLASTIC LOGIC

093



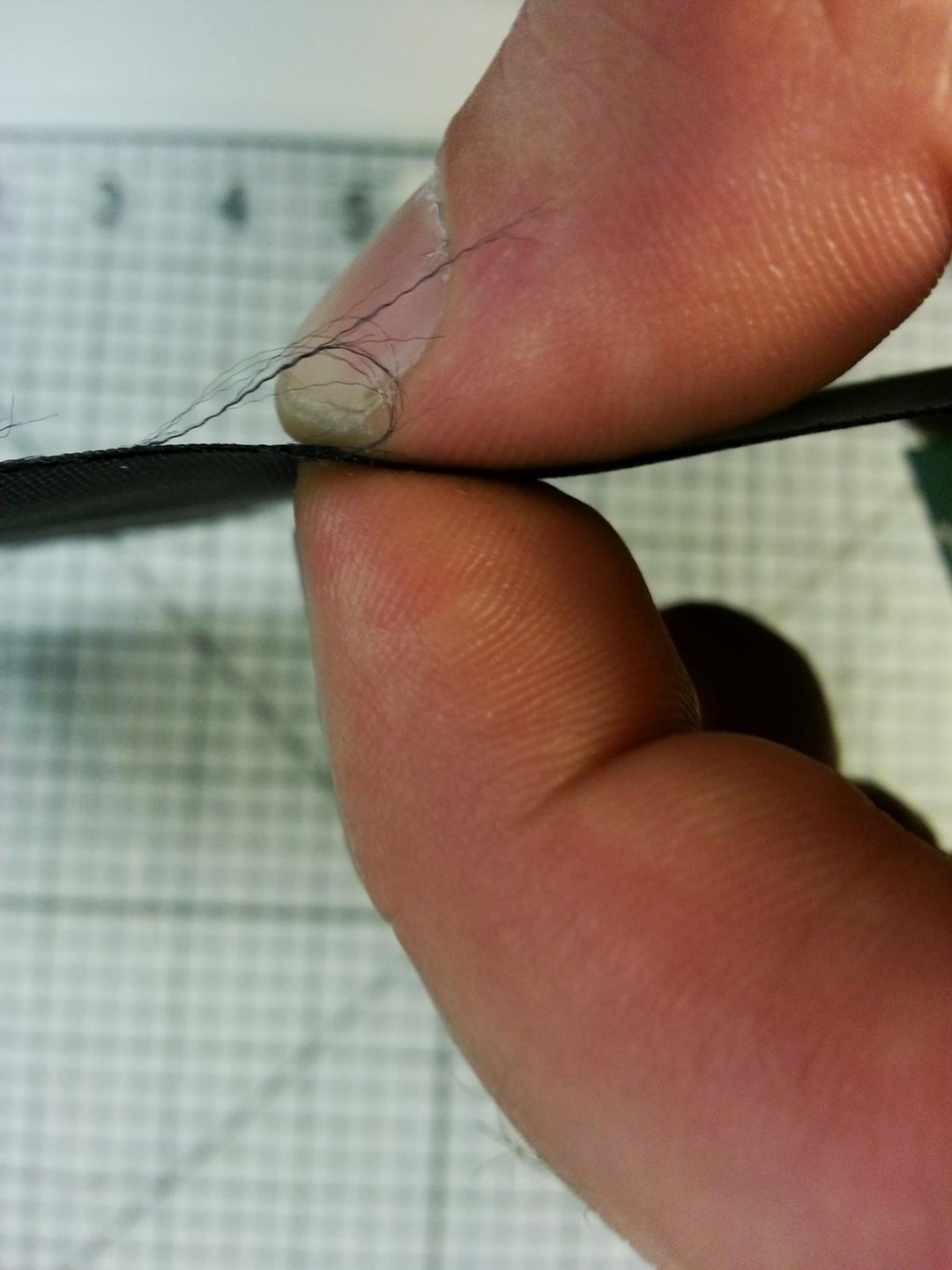
PLASTIC LOGIC
Z1 MPWB rev1.1

PLASTIC LOGIC
Z1 MPWB rev1.1

DURATION

1:13:34

D33







A person's hands are holding a black, rectangular pouch. In the center of the pouch is a white rectangular label. The label has the word "DISTANCE" in a small, sans-serif font at the top. Below it, the number "10.4" is printed in a large, bold, sans-serif font. To the right of the number, the word "miles" is printed in a smaller, sans-serif font. The background is a plain, light-colored surface.

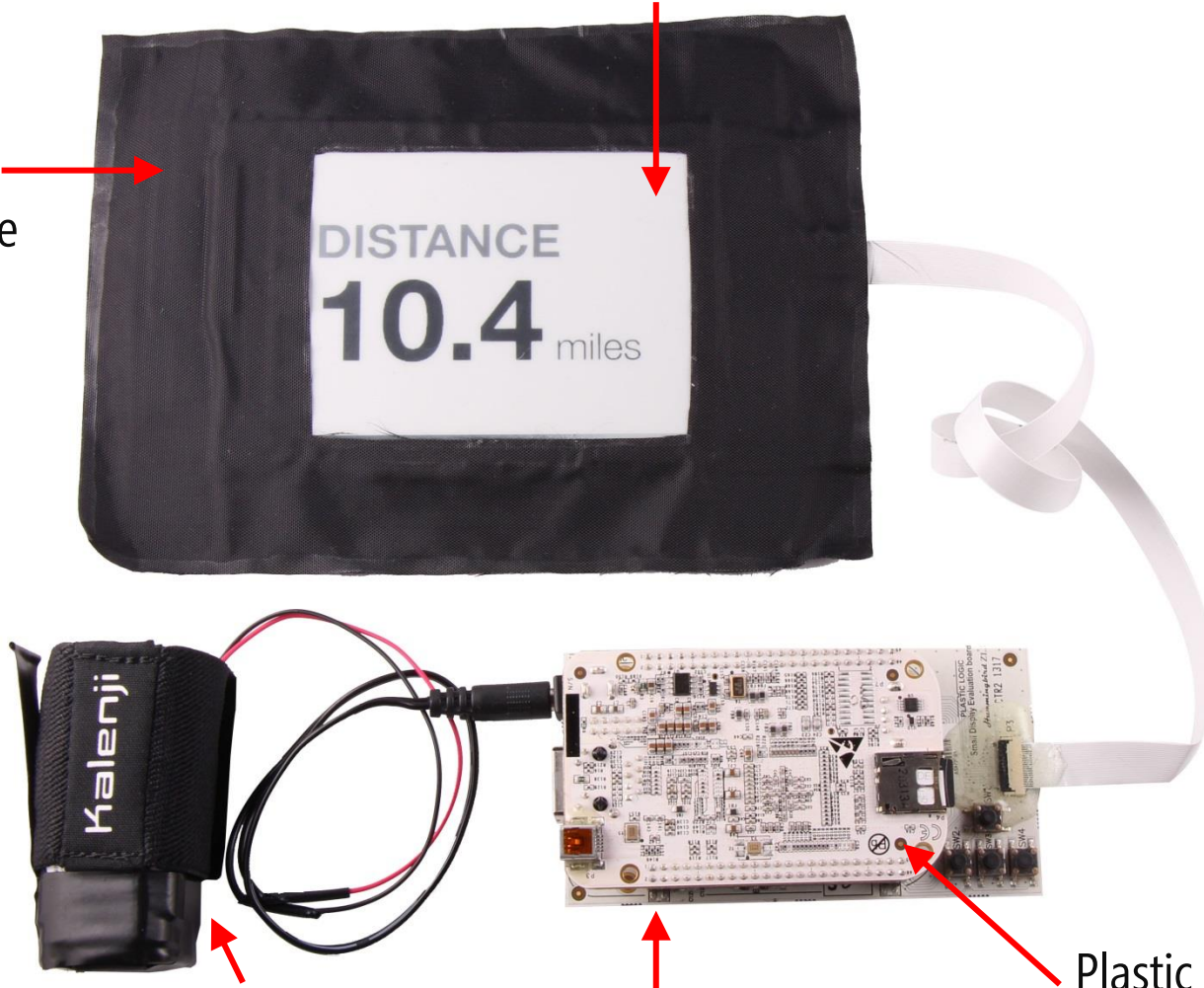
DISTANCE
10.4 miles

Prototype #2

Final e-Ink Prototype

Plastic Logic Flexible e-Ink
Display 4.7" (320 x240)

Nylon
Enclosure

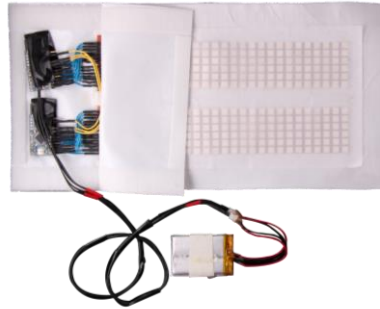


4 x 1.5V (2000 mAh)
AA Batteries

32-bit BeagleBone
(AM335x 720MHz ARM)

Plastic Logic Display
Controller (HummingBird)

SFF: THREE PROTOTYPES



Prototype #1



Prototype #2

Display Weight	66.9 g
Total Weight	152.9 g
Pixels	24 x 12
Refresh Rate	5 Hz
Dimensions*	21.3 x 12.2 cm
Display Thickness*	13.5 mm

* With enclosure

Prototype #1

Custom LED Matrix Display



Prototype #2

Electronic Ink Display



Prototype #3

Erogear LED Matrix Display



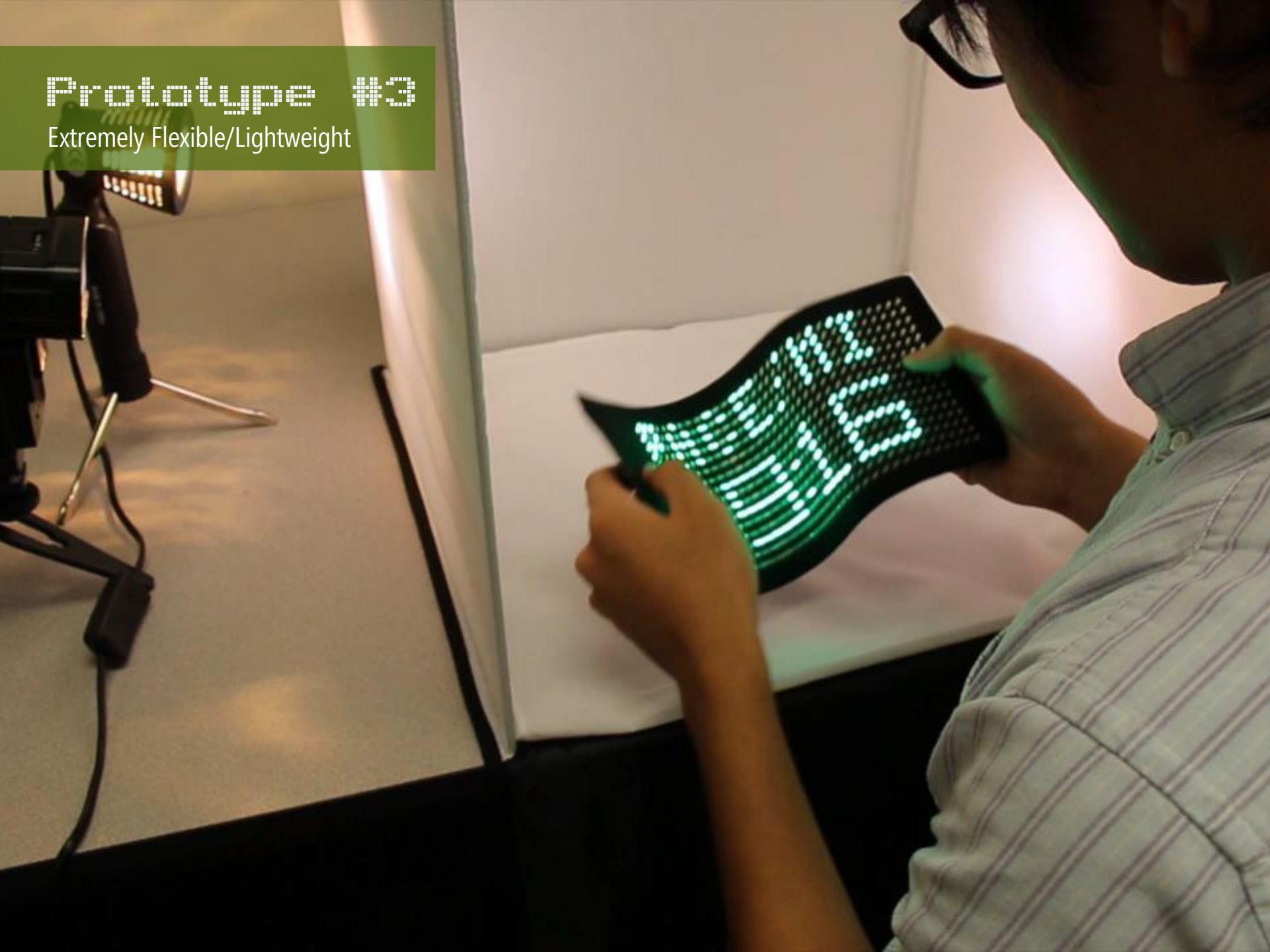
Prototype #3

Early Erogear Visualizations



Prototype #3

Extremely Flexible/Lightweight

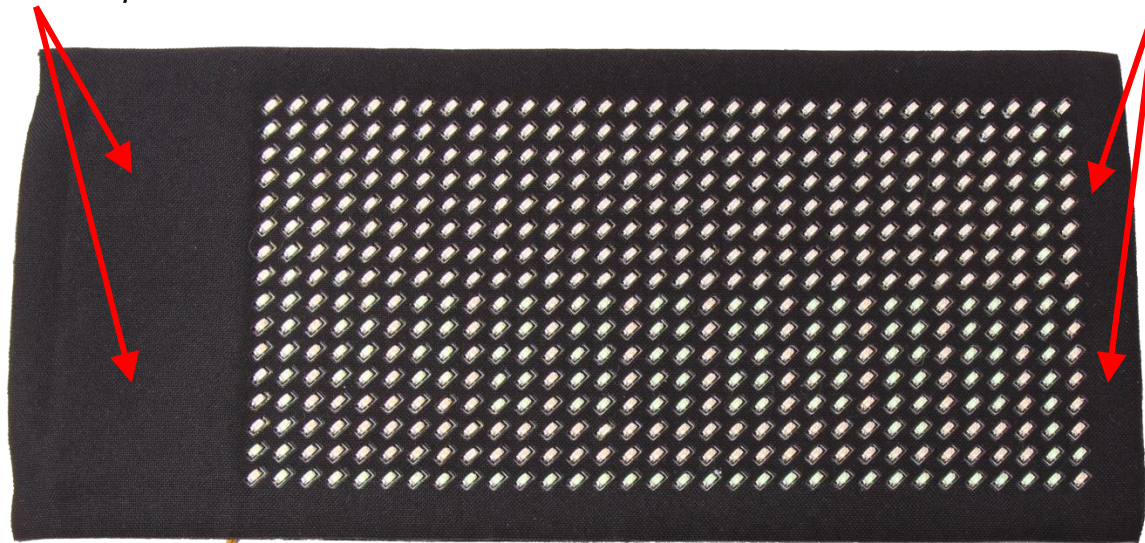


Prototype #3

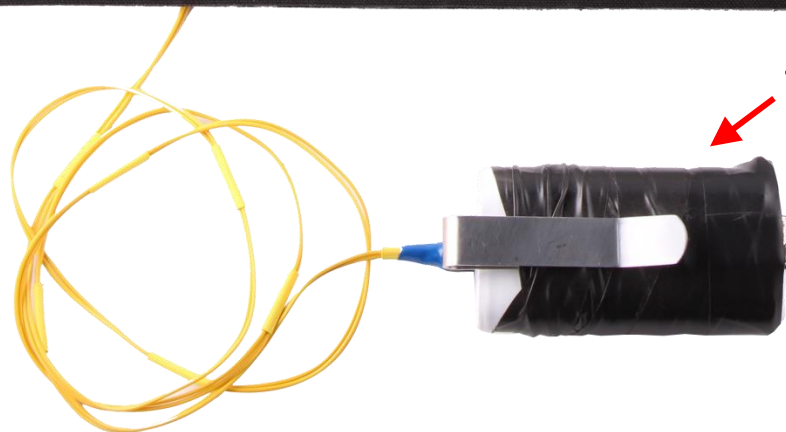
Final Erogear Prototype

2 x 32-bit MCU; 16-bit LED Matrix
Driver; Bluetooth Modem

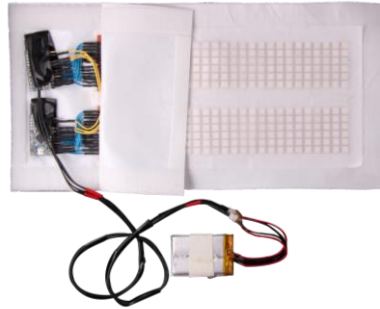
2 x 32x8 Erogear
LED Matrices



2 x 3.7V (2200 mAh)
Li-Ion Batteries



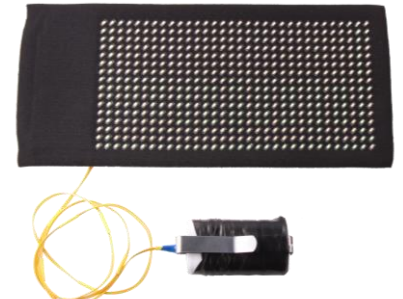
SFF: THREE PROTOTYPES



Prototype #1



Prototype #2



Prototype #3

Display Weight	66.9 g	25.4 g
Total Weight	152.9 g	411.7 g
Pixels	24 x 12	320 x 240
Refresh Rate	5 Hz	1.1 Hz
Dimensions*	21.3 x 12.2 cm	18.4 x 14 cm
Display Thickness*	13.5 mm	4.9 mm

* With enclosure

SFF: DESIGN AND EVALUATION PROCESS

Ideation &
Lo-Fi Proto.

Parallel Prototyping
3 Designs

Refine
Final Design

Field Study of 10
Running Groups

2 Race
Studies

Informal Pilot Studies

Final
Pilots

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Evaluate Comfort



Examine Viewability



Investigate Robustness



Gain qualitative reactions

Prototype #3



Pilot Studies

In-situ observation



Prototype #1



Prototype #2

Data Collection

In-situ observation



Data Collection

Pre- and Post-Surveys



Viewability

Examining Diffusion Layers



Viewability

Prototype #1 & #2



Viewability

Prototype #1 & #2



Viewability

Prototype #3: Lighting Conditions



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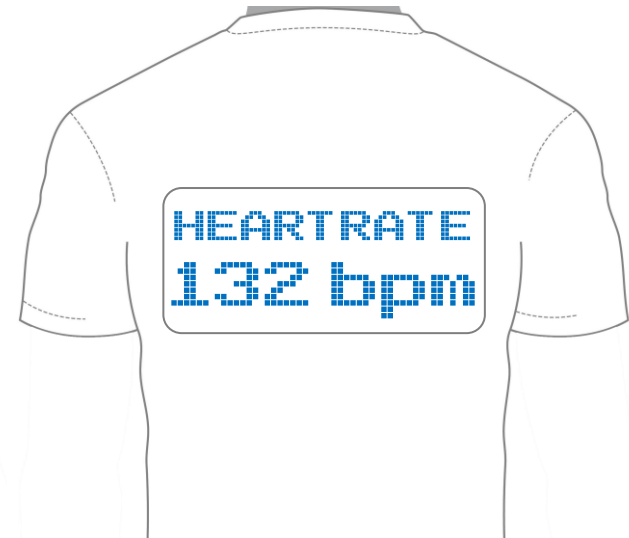
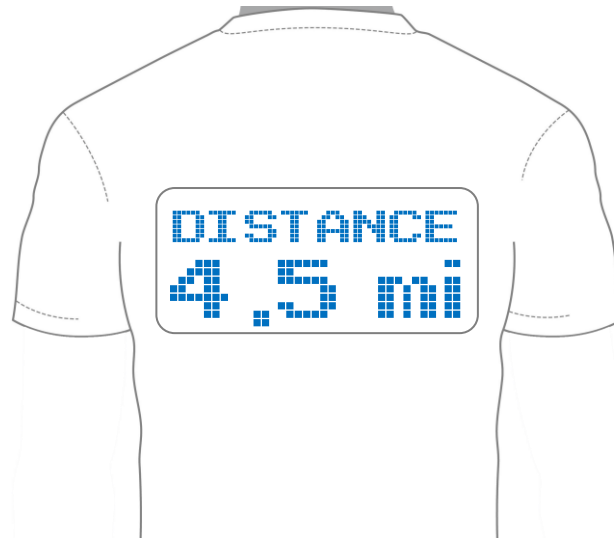
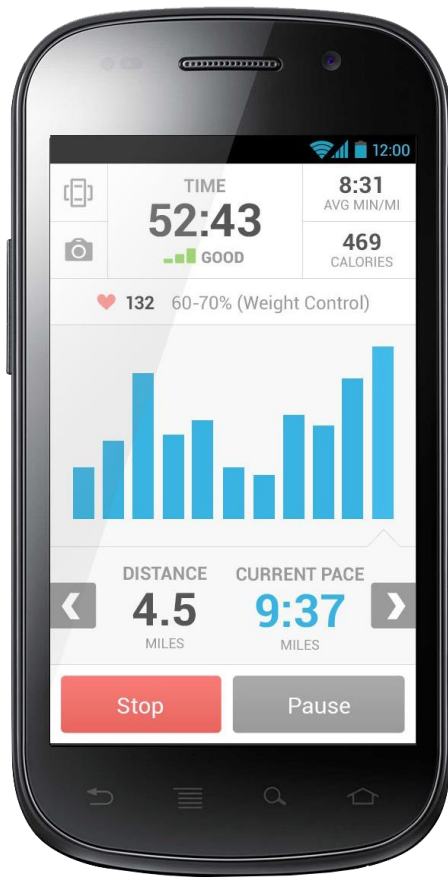
Final
Pilots

Prototype #3

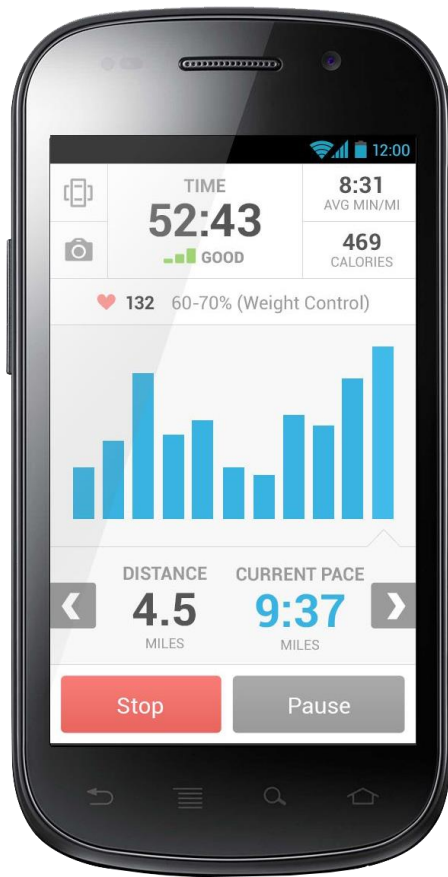
Erogear LED Matrix Display



SFF: PRIMARY VISUALIZATIONS



SFF: FINAL VISUALIZATIONS



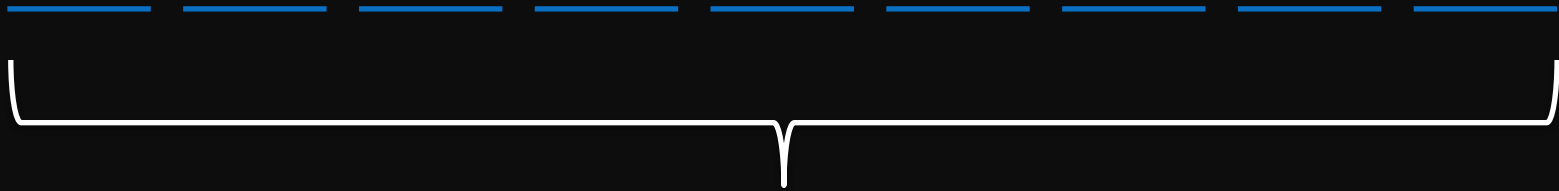
SFF: SHARED GOAL VISUALIZATION

Group set target pace

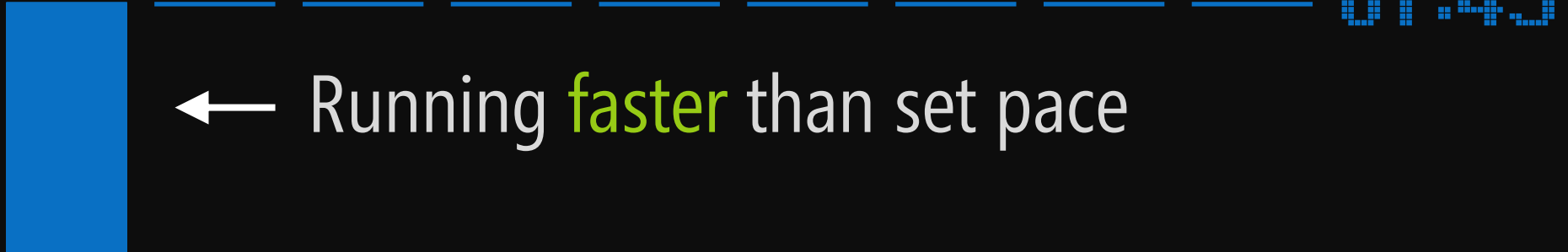


07:45

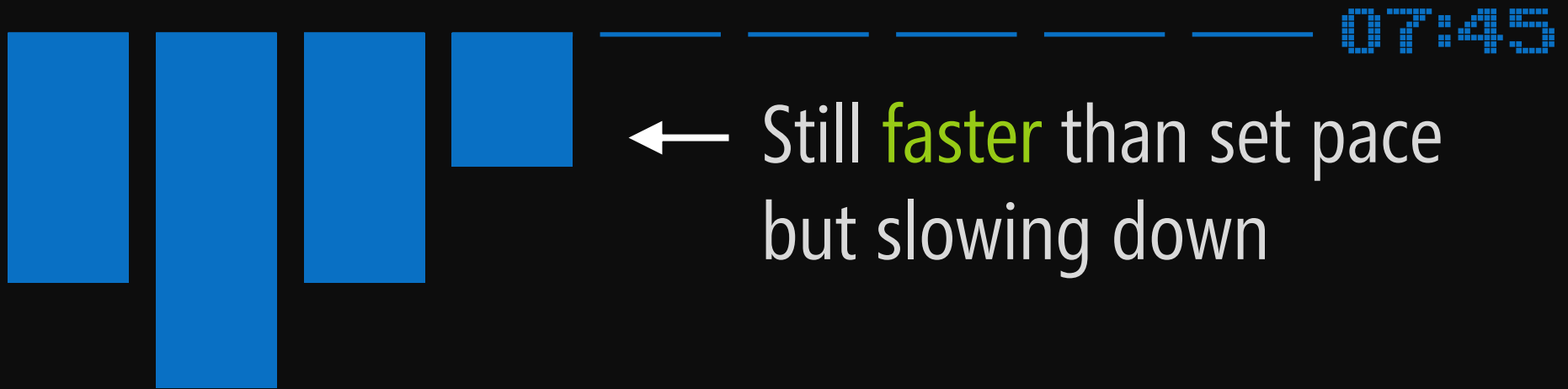
Last 9 mins of the run



SFF: SHARED GOAL VISUALIZATION

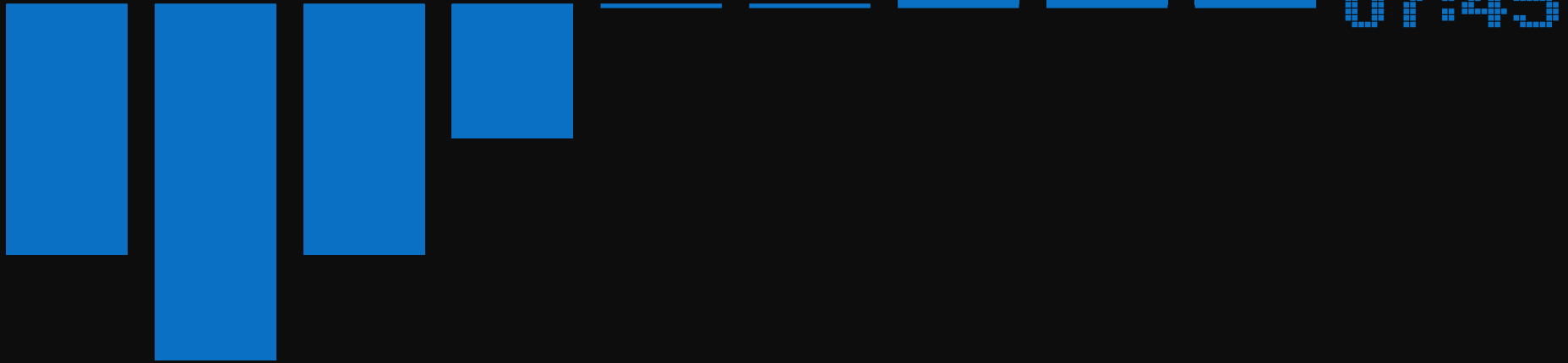


SFF: SHARED GOAL VISUALIZATION



SFF: SHARED GOAL VISUALIZATION

Now running **slower** →
than set pace



Final Prototype

Shared Goal Visualization



SFF: Design and Evaluation Process

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Lo-Fi Proto.

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SFF: Design and Evaluation Process

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makeability lab



Running Groups Needed to Help Evaluate New Wearable Running Technology

Do you run? Do you run in groups? We need your help! In our study, we are looking for existing groups of runners (3 or more) to assist us as volunteers in a research project exploring e-textile athletic jerseys.

Specifically, we have designed and constructed prototype athletic jerseys that communicate running information such as pace, duration, and distance via a live, wearable display. As a participant, your role is to help us better understand how these jerseys impact your sense of the run activity and the runners around you.

For the study, we will ask you to first complete a short demographic and pre-activity survey. Then, you will perform a short running activity of 20 – 35 minutes (depending on your preference) with the group. One (or two) people in the running group will be wearing our e-textile jersey along with a provided mobile phone and arm strap. After completing the run, you will be asked to fill out a short survey about your experience. The entire session should last approximately 60 minutes.

Participants will be reimbursed \$20 per hour for their time. Study sessions will be conducted on the University of Maryland, College Park campus or, in some cases, at a specific physical location of your choice. All participants must be 18 years of age or older and be an active runner. Apart from that restriction, we encourage people of all genders and ethnicities to participate. If you are interested in participating, please email Matthew Mauriello (mattm@cs.umd.edu) the following information:

- How often you run (e.g., once a week, three times a week)
- How often you run in a group and the typical group size
- How you currently track your runs (e.g., Nike+, Runkeeper, paper + pen)

Feel free to take a look at our research lab's website to find out more about our research program: <http://www.cs.umd.edu/hcil/>. Please also feel free to redistribute this posting.

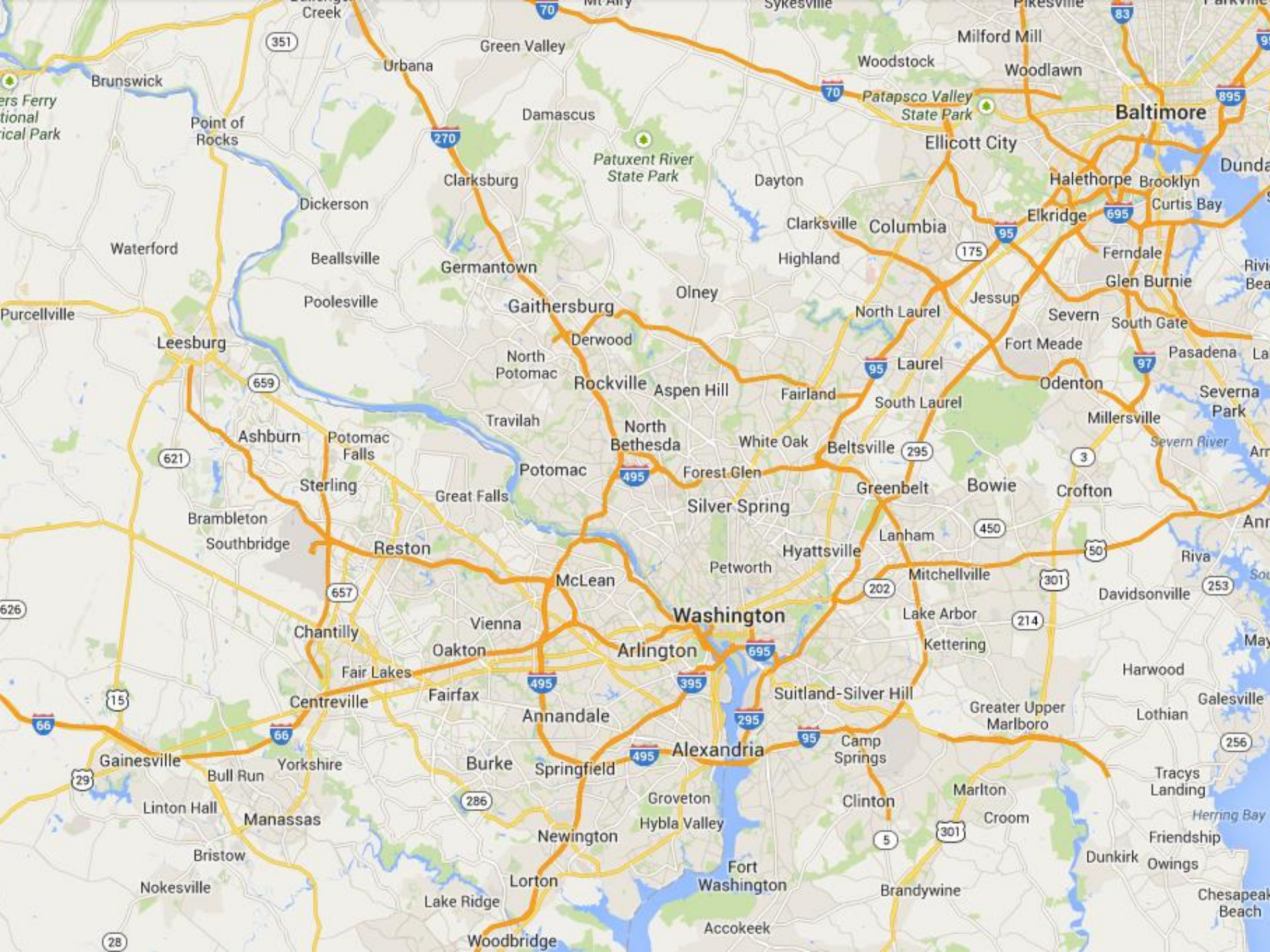
Sincerely,

~Matthew Mauriello, MS
Department of Computer Science
University of Maryland
A.V. Williams Building, 4122
College Park, MD 20742

--

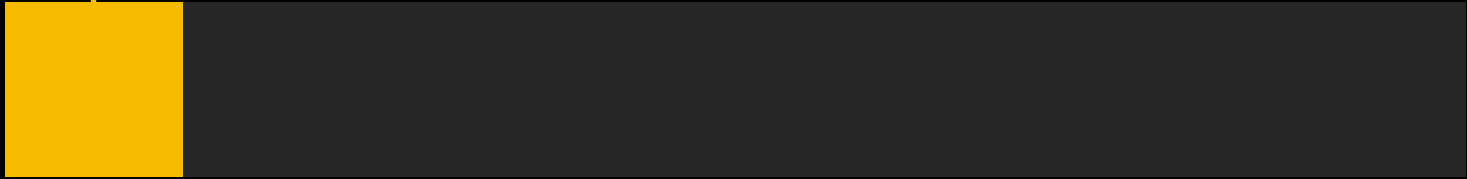
<http://www.cs.umd.edu/~mattm/>
Twitter @mattm401



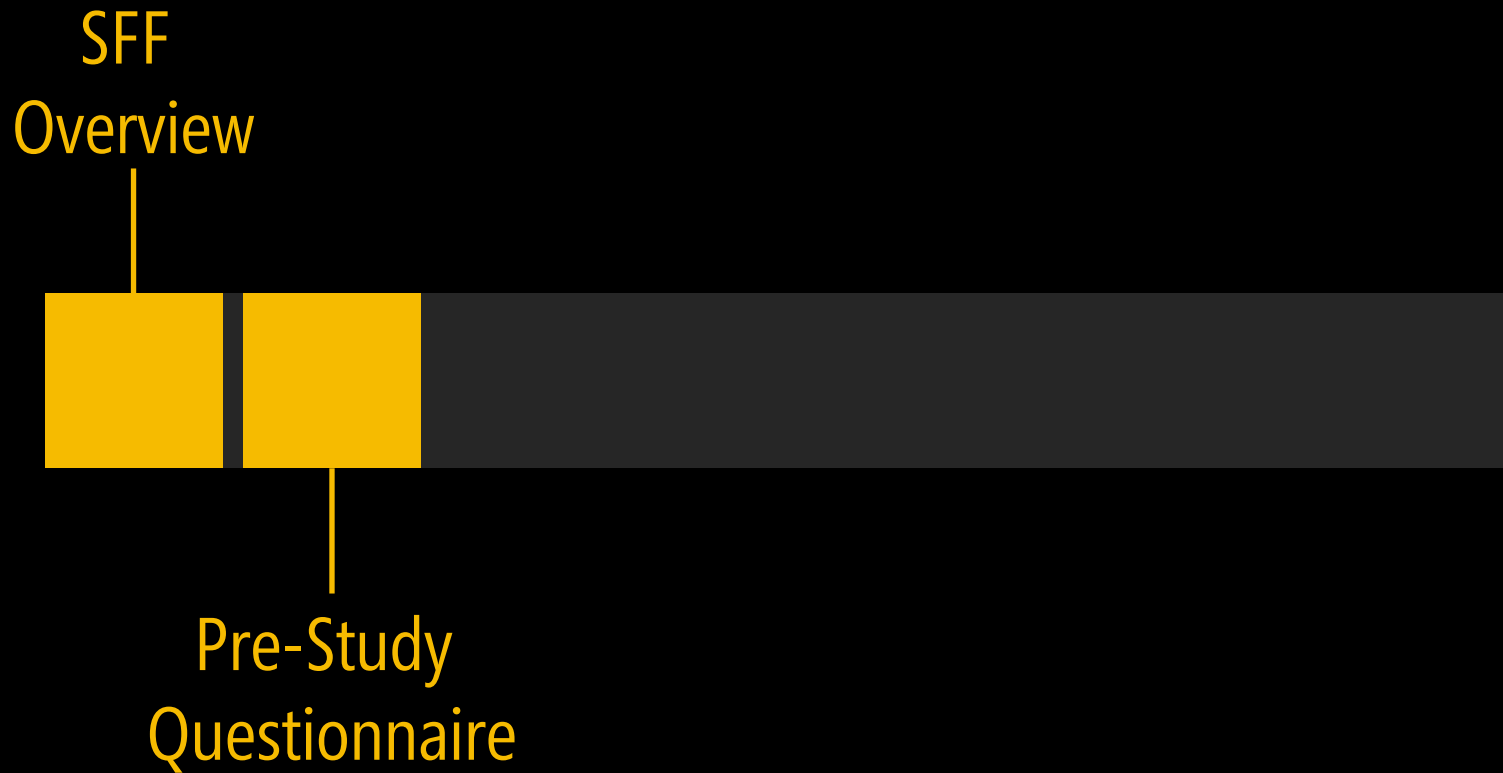


SFF: STUDY PROCEDURE

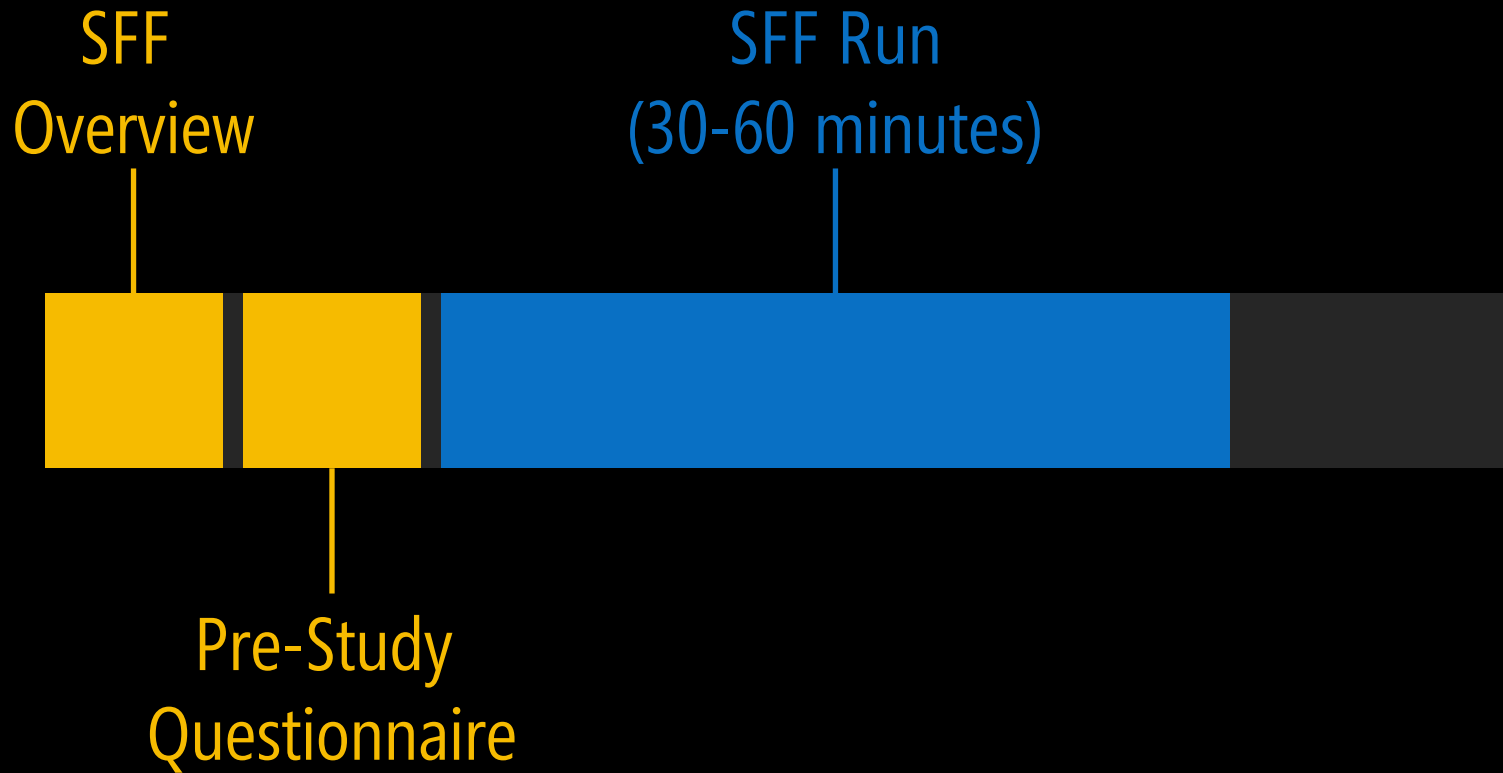
SFF
Overview



SFF: STUDY PROCEDURE



SFF: STUDY PROCEDURE





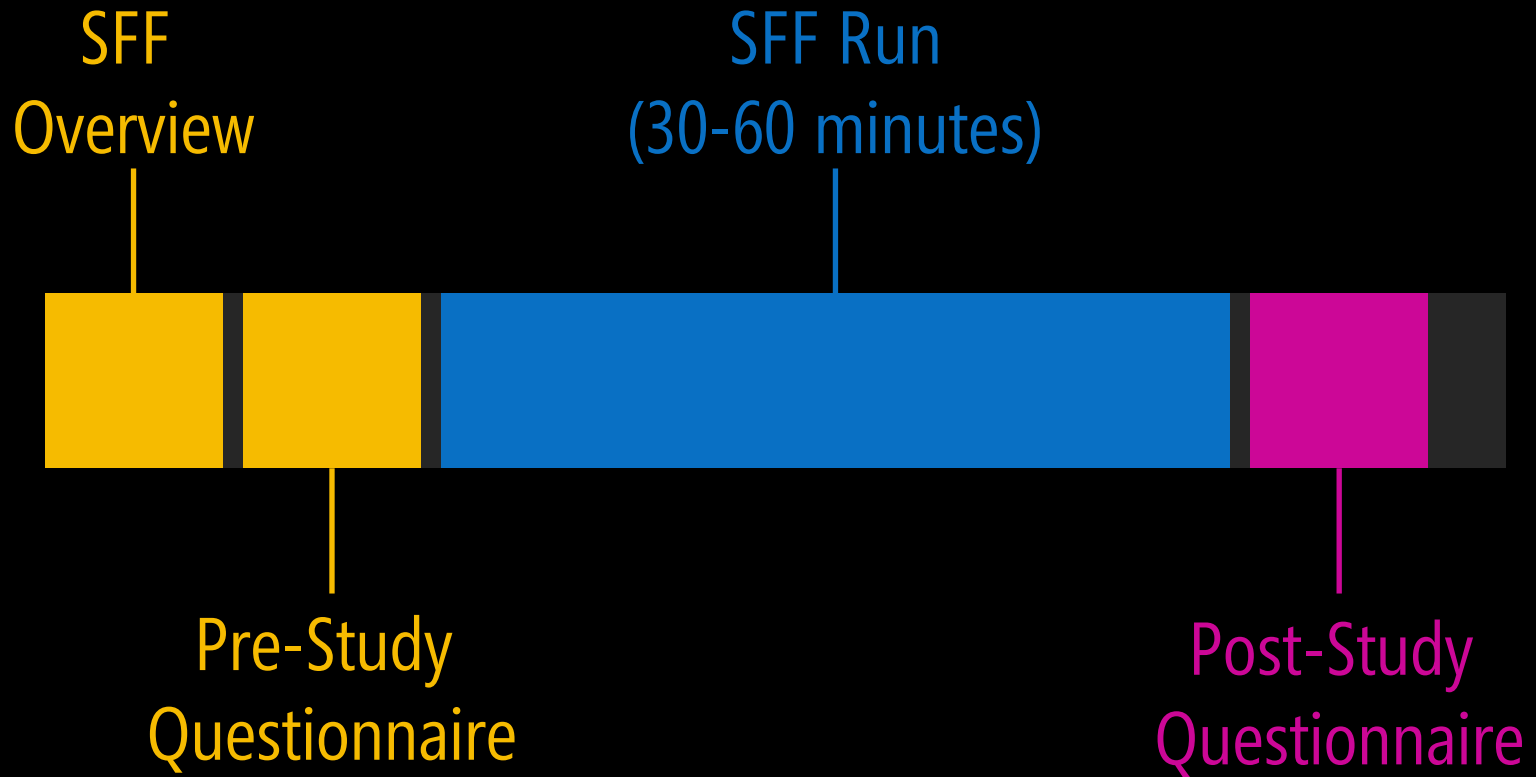


PACE
11.16

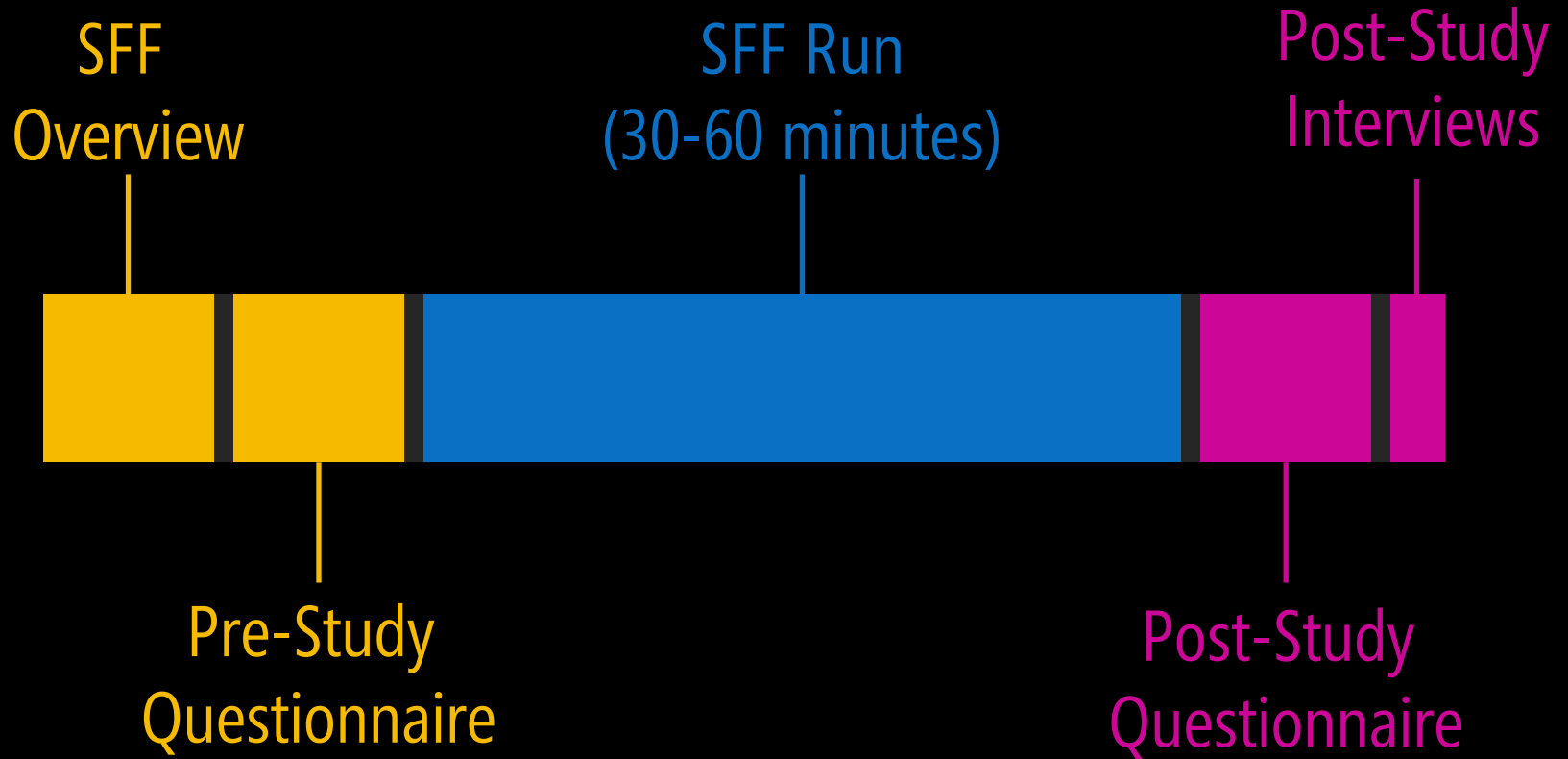
15.1

RUNNING STRONG
FOREVER

SFF: STUDY PROCEDURE



SFF: STUDY PROCEDURE



5:30AM

Obligatory Red Bull



FIELD STUDY PARTICIPANTS

10 GROUPS; 52 INDIVIDUALS (35 FEMALE)



Avg Group Size:

5

Avg Age:

40.7

Avg Target Pace:

10:14

Avg Distance:

3.5 mi

SFF: ANALYSIS

We analyzed the Likert scale survey data to uncover trends and use the interview and open-form data to provide context.

SFF: FIELD STUDY RESULTS



Comfort



User Experience



Display Content



Cohesiveness



Awareness



Self-Consciousness



Motivation



Other Technology

SFF: FIELD STUDY RESULTS



Comfort



Display Content



Awareness



Motivation



User Experience



Cohesiveness



Self-Consciousness

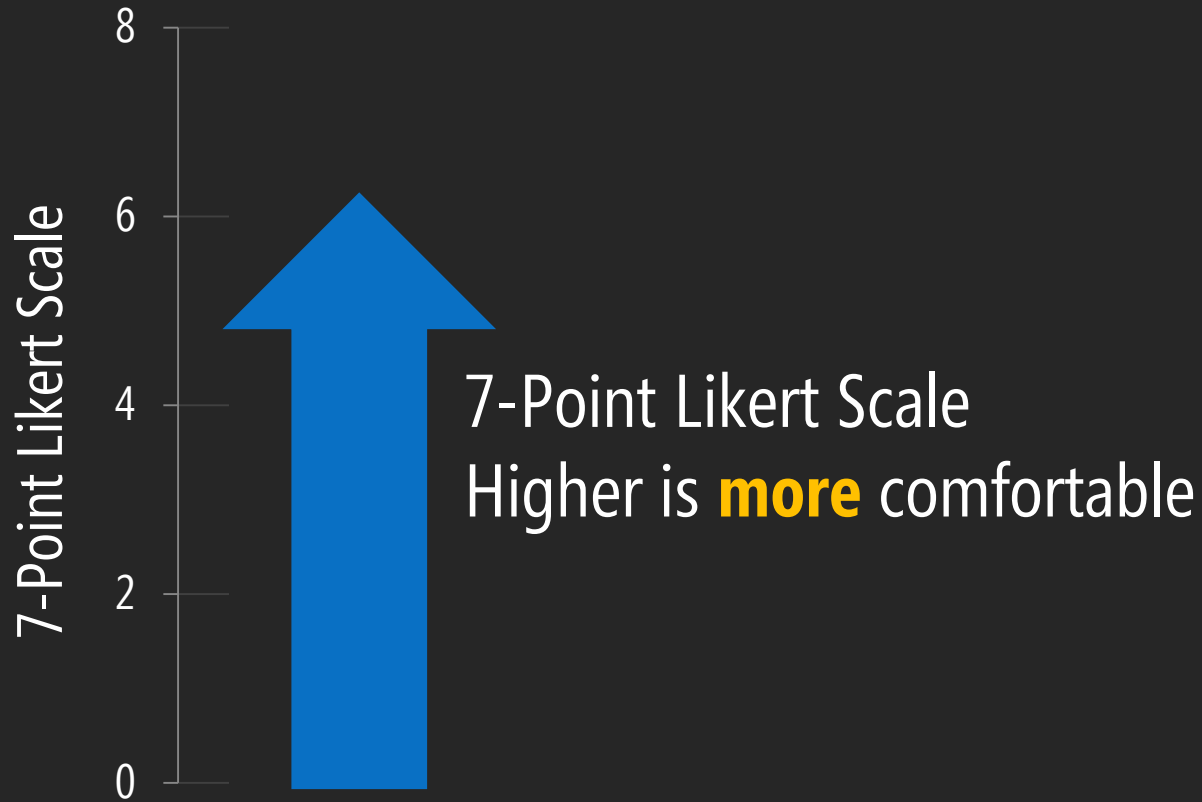


Other Technology



FIELD STUDY RESULTS

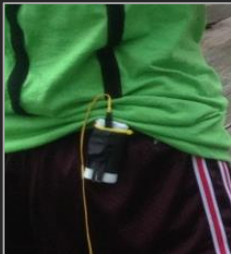
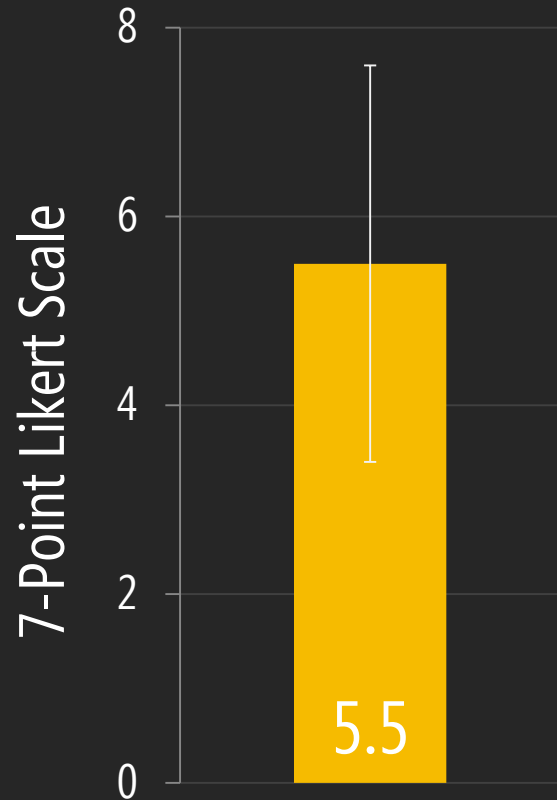
COMFORT; WEARERS (N=19)





FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)

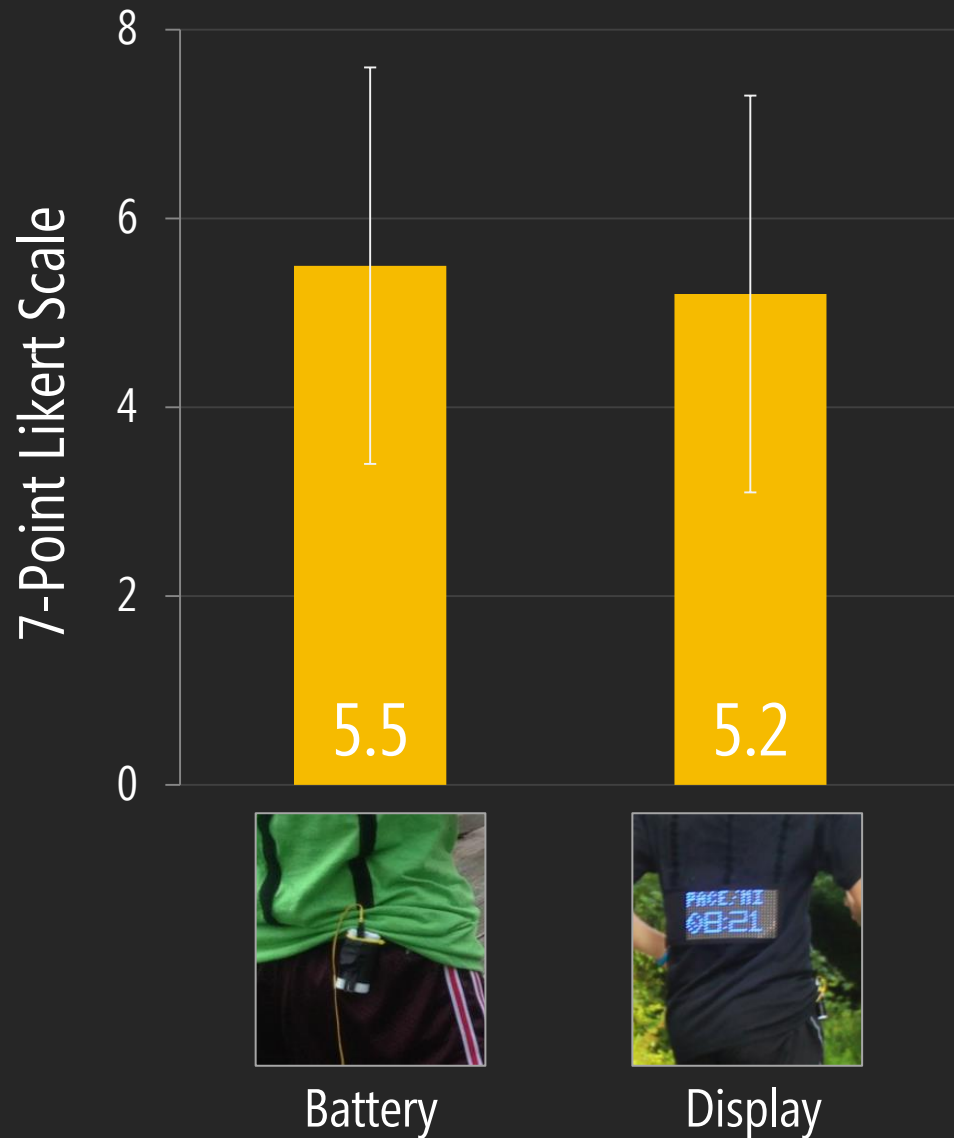


Battery



FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)





FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)

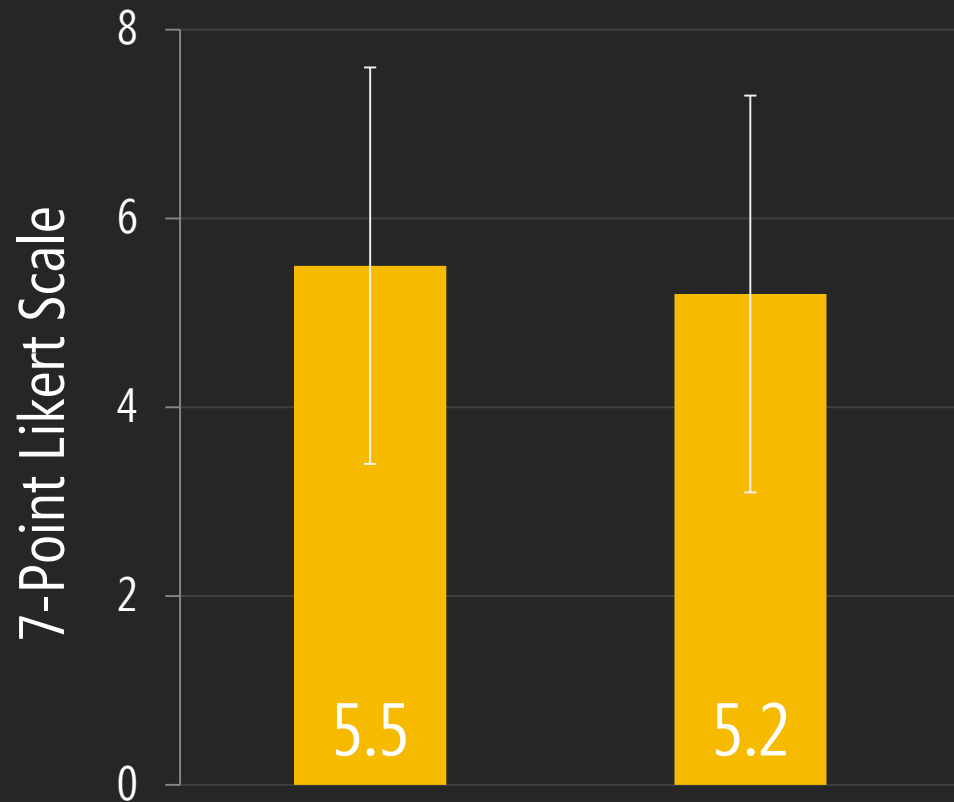
"I thought [the system] would be uncomfortable; it turned out to be unnoticed."

-G5P2-W



FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)



Battery



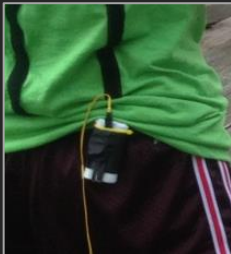
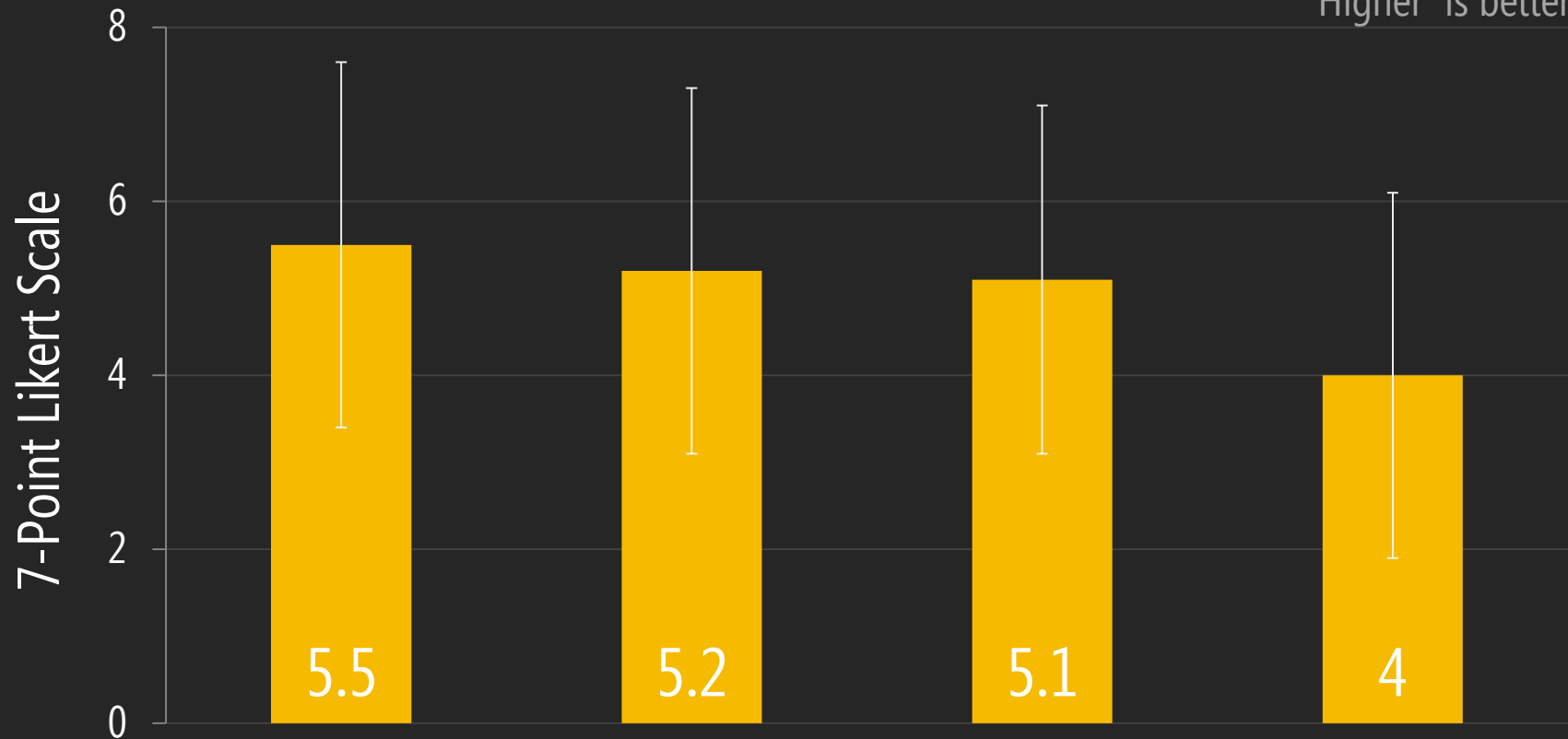
Display



FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)

Higher is better



Battery



Display



Heart Monitor



Armband



FIELD STUDY RESULTS

COMFORT; WEARERS (N=19)

"Armband is heavy; other
[equipment] was fine..."

-G2P1-W

SFF: FIELD STUDY RESULTS



Comfort



Display Content



Awareness



Motivation



User Experience



Cohesiveness



Self-Consciousness



Other Technology



FIELD STUDY RESULTS

DISPLAY CONTENT; ALL (N=52)

Rank Order List

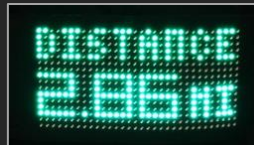
Average Scores

Pace



1.5

Distance



2.2

Duration



3.1

Visualization



3.9

Heart Rate



4.3

SFF: FIELD STUDY RESULTS



Comfort



Display Content



Awareness



Motivation



User Experience



Cohesiveness



Self-Consciousness



Other Technology



FIELD STUDY RESULTS

DATA AWARENESS; ALL (N=52)

"It made me more aware of our pacing and kept me more focused on the run."

-G2P2-W



SFF: FIELD STUDY RESULTS



Comfort



Display Content



Awareness



Motivation



User Experience



Cohesiveness



Self-Consciousness



Other Technology



FIELD STUDY RESULTS

MOTIVATION; ALL (N=52)

"Made me feel like I was pushing my efforts, which is good."

-G7P8

"Motivated me to go faster than the pace displayed."

-G7P7

SFF: FIELD STUDY RESULTS



Comfort



Display Content



Awareness



Motivation



User Experience



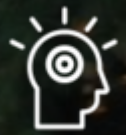
Cohesiveness



Self-Consciousness



Other Technology

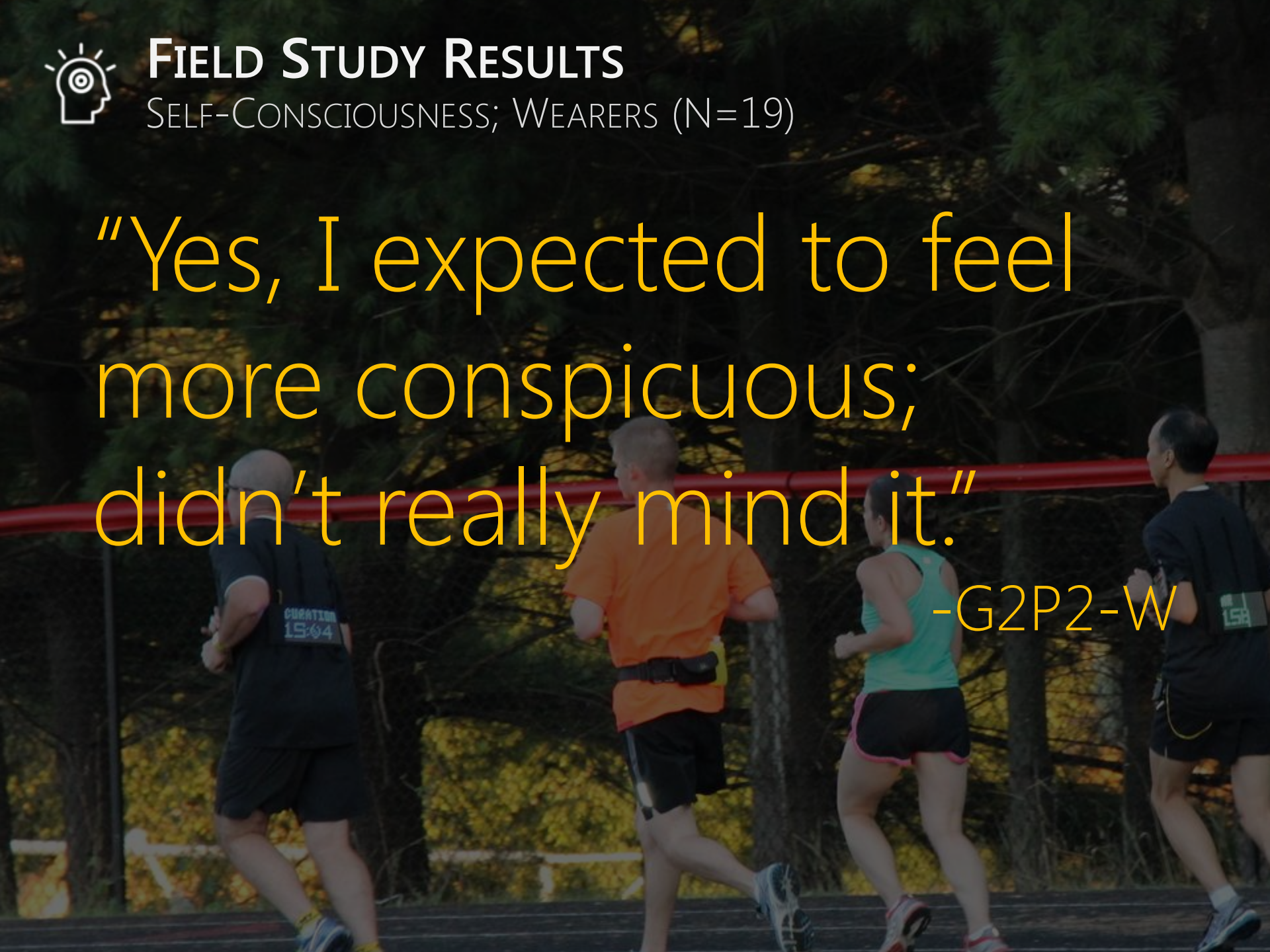


FIELD STUDY RESULTS

SELF-CONSCIOUSNESS; WEARERS (N=19)

"Yes, I expected to feel
more conspicuous;
didn't really mind it."

-G2P2-W



SFF: DESIGN AND EVALUATION PROCESS

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RACE STUDY PARTICIPANTS

4 INDIVIDUALS (1 FEMALE)



Male, 34

Target Pace: 6:10

County 8K



Female, 33

Target Pace: 8:20

County 8K



Male, 26

Target Pace: 7:45

Labor Day 10K



Male, 18

Target Pace: 8:30

Labor Day 10K

Race Deployment

Competitive Interactions

Gold Medal





RACE STUDY RESULTS

MOTIVATION; WEARERS (N=4)

"It made me run faster
because my performance
was on display."

-R2P1-W

Limitations



Limitations



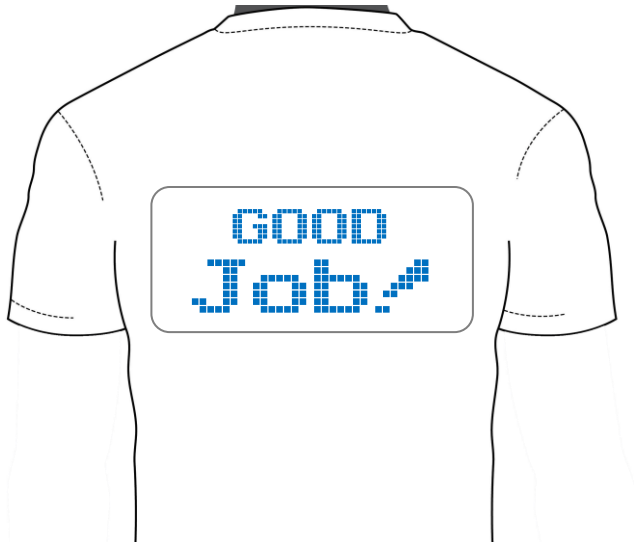
Novelty



Observational Bias

Future Work

Encouragement



Future Work

Social Media Integration



twitter

Future Work

Cross Domains



Summary

This work contributes to two rapidly growing areas: **personal informatics** and **wearable technology**.

Through parallel prototyping, iterative design, and **exploratory studies** we demonstrate the potential to **motivate group fitness performance** with wearable technology.

Our Research Team:



Matt Mauriello
@mattm401



Michael Gubbels
@mokogobo



Jon Froehlich
@jonfroehlich

Thanks to our collaborators:
RunKeeper and **Erogear**

Thanks to **Nokia** for funding

